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INCLUDING PRESTRESSED CONCRETE

NOVEMBER 1960 **VOL. LV. NO. 11**

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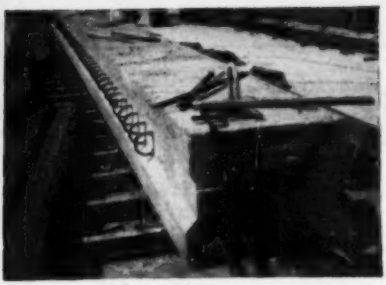

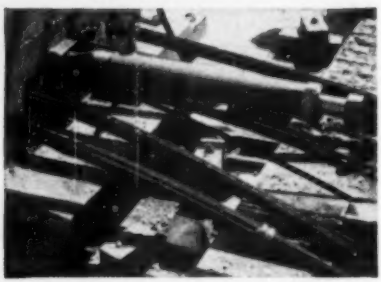

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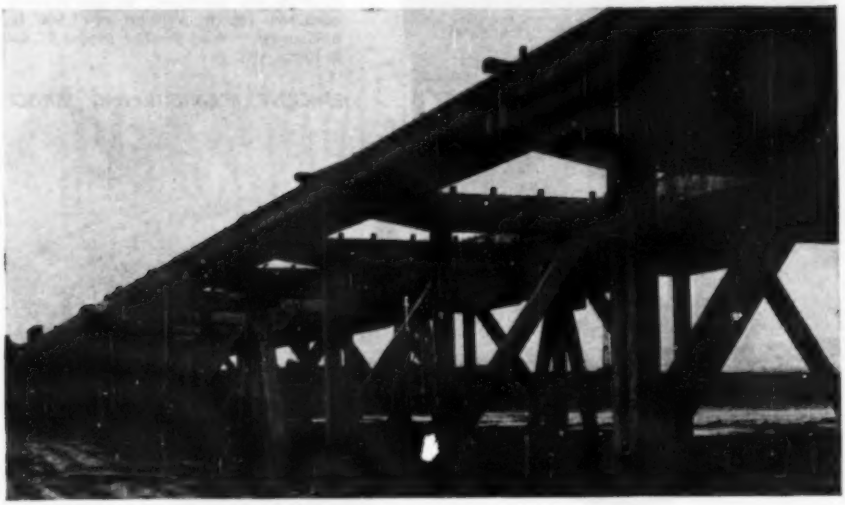

This illustration of the approach to the super-tanker berths at Tranmere is reproduced by courtesy of the Mersey Docks and Harbour Board. Construction is being carried out under the direction of their Engineer-in-Chief.

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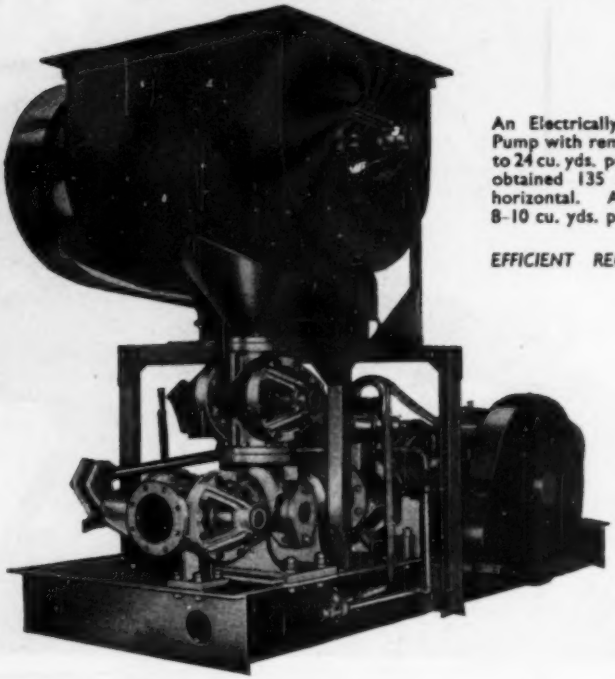

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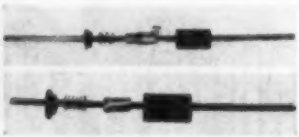

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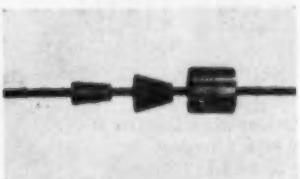

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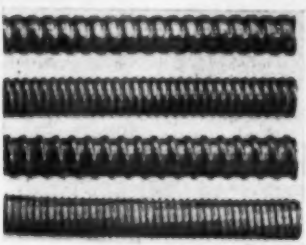

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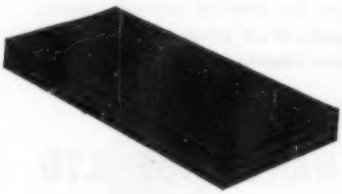

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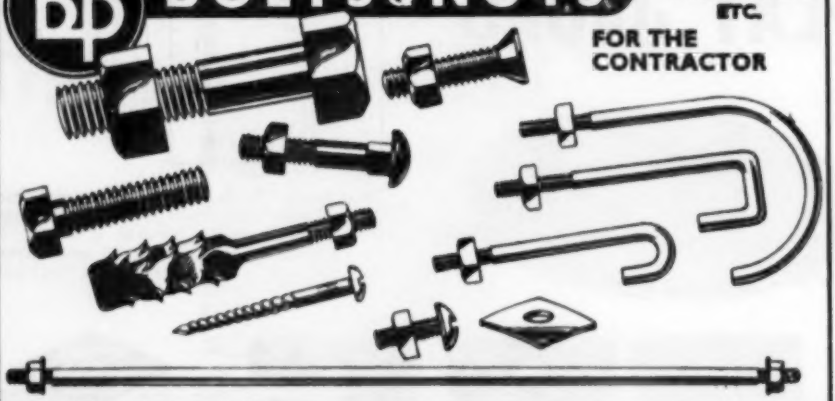

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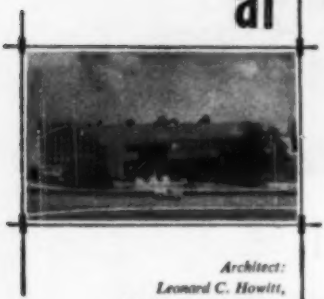

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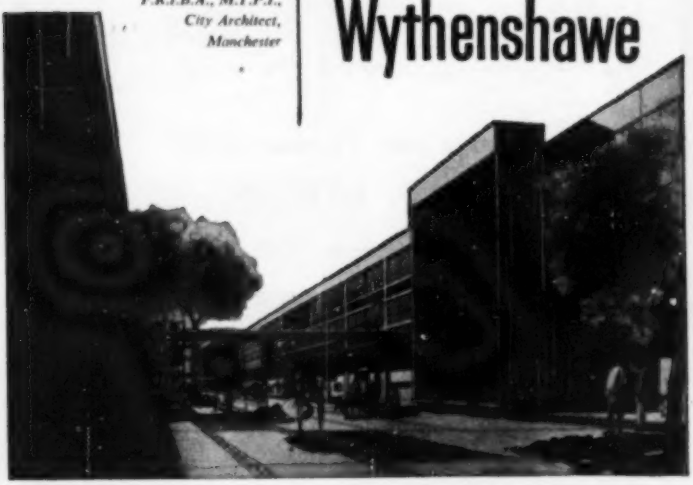

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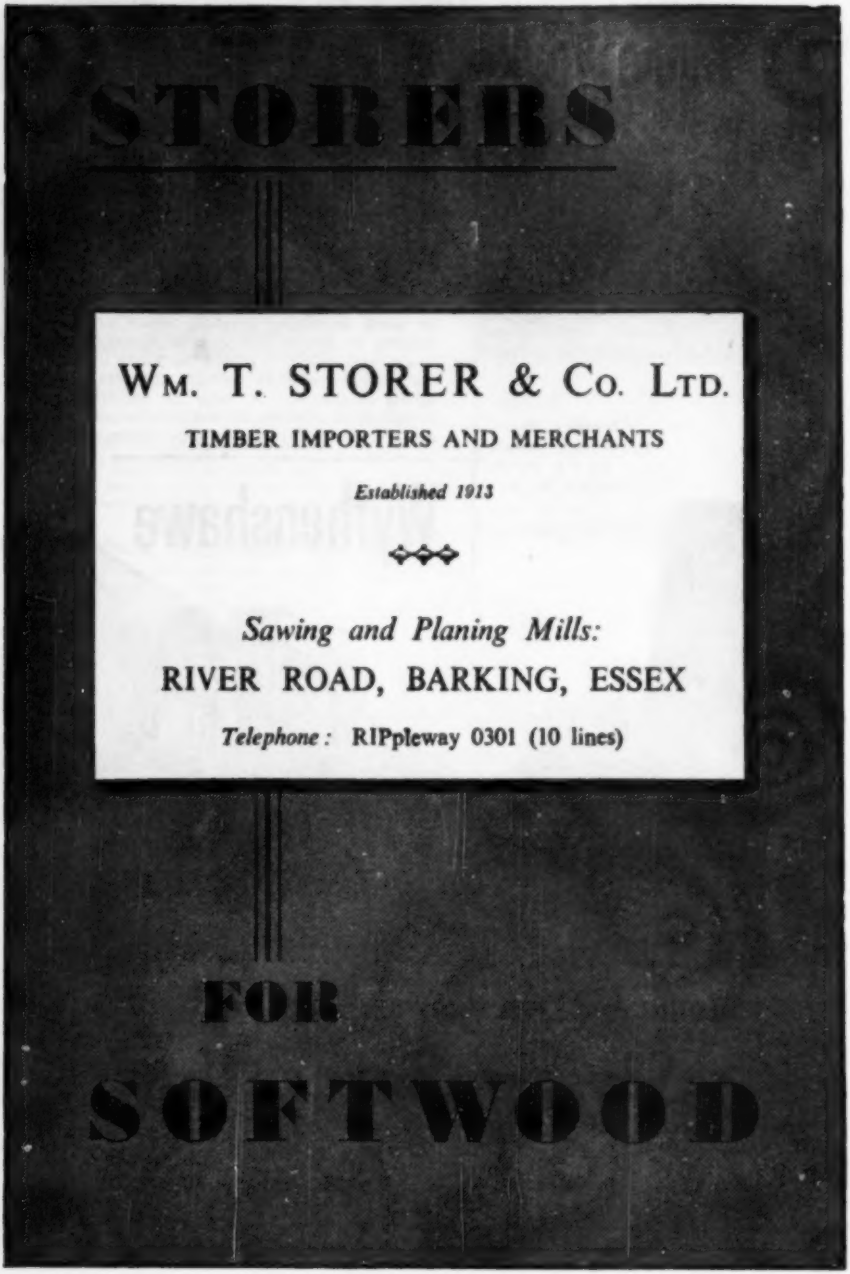
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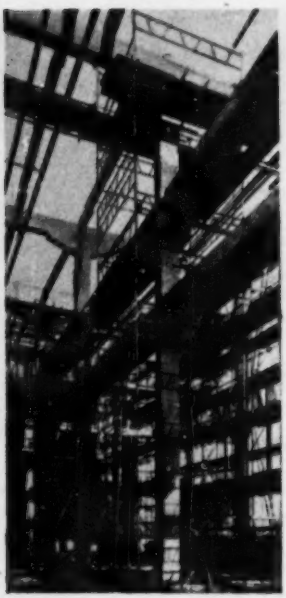

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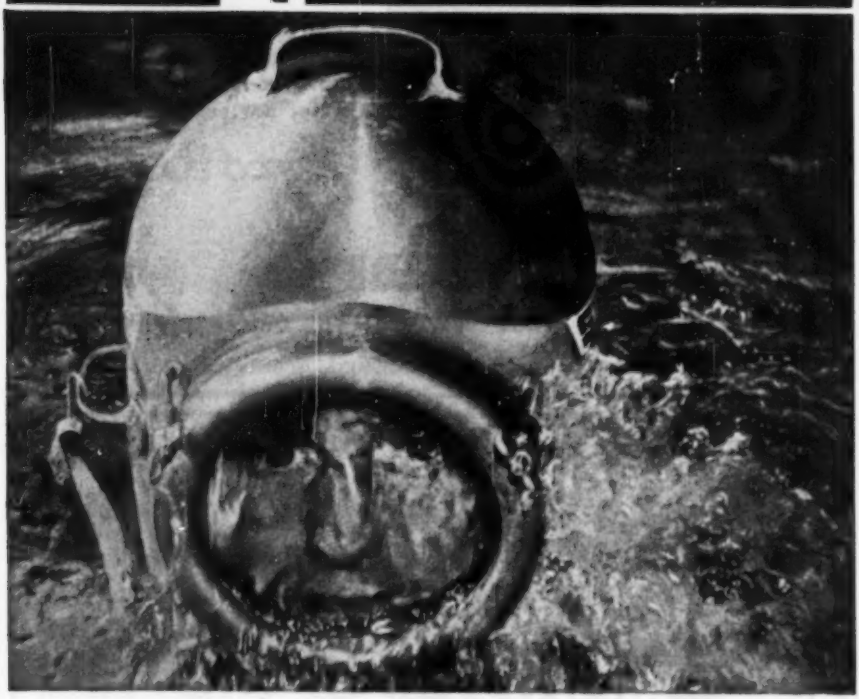

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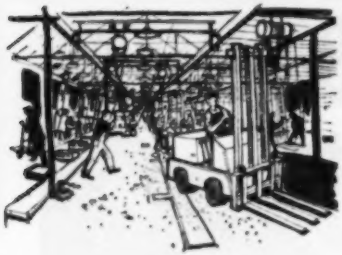

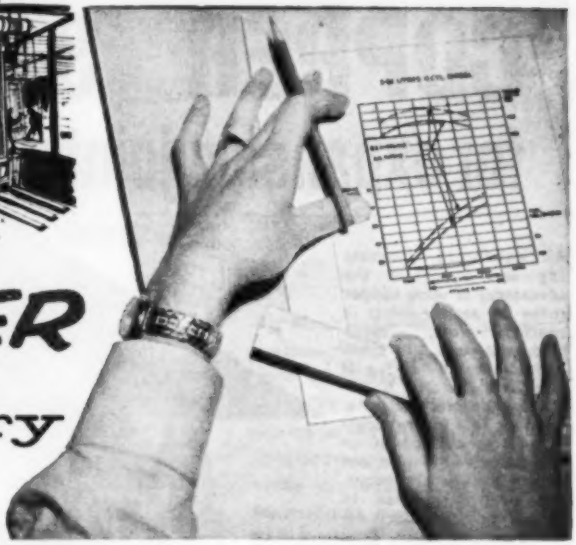

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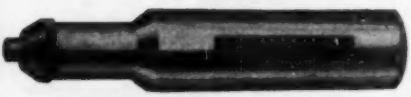

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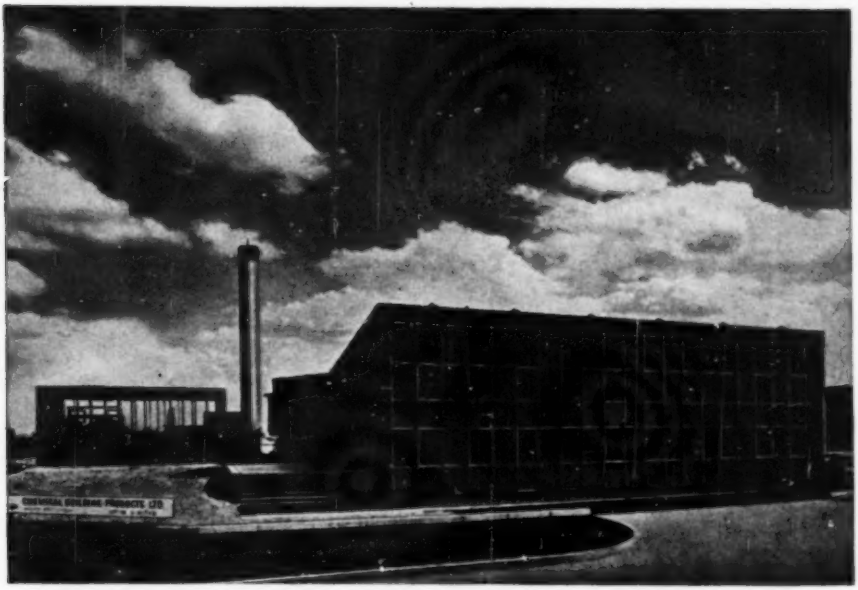

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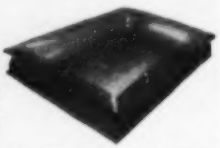

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In response to many requests, the article and tables by Mr. Jacques S. Cohen, in this journal for August, 1957, have been reprinted together with an additional table. These tables enable any rectangular section to be quickly designed by both the elastic method and the load-factor method, and the relative economy of the results of each method of design can be seen at a glance. The price of the reprint is 4s. (4s. 3d. by post); 1 dollar in Canada and the U.S.A.

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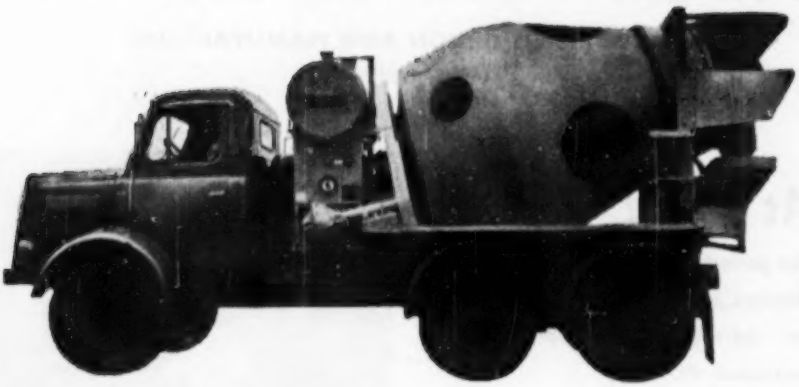

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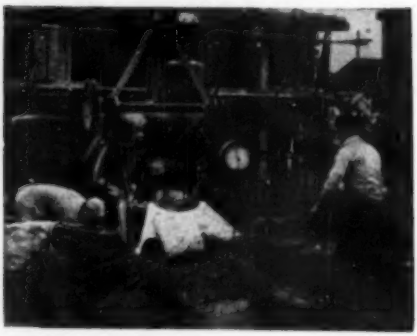

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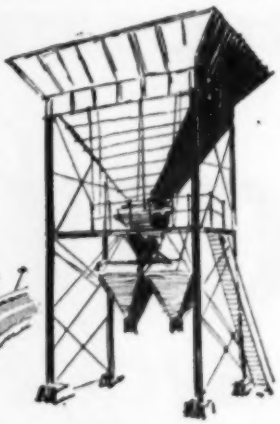

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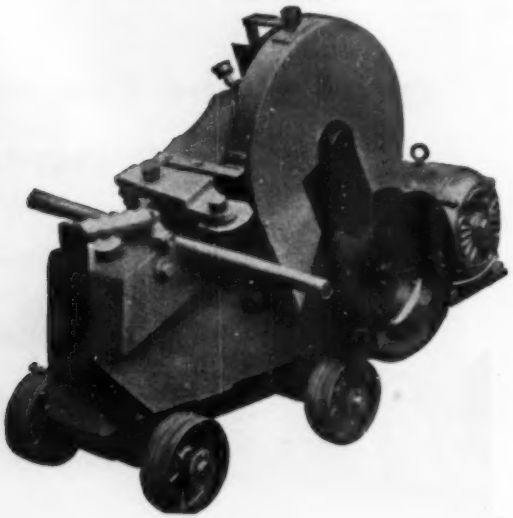

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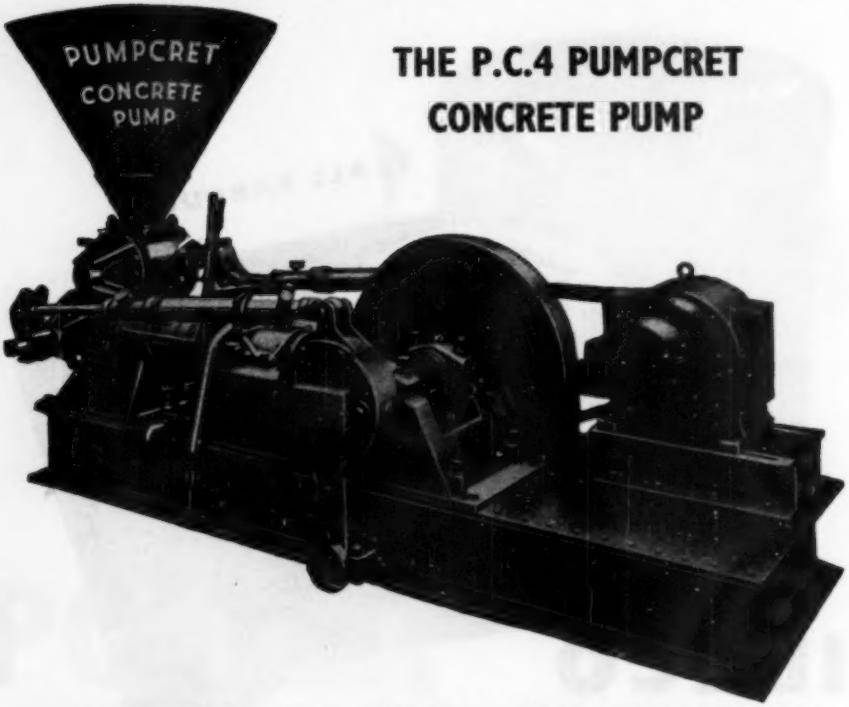

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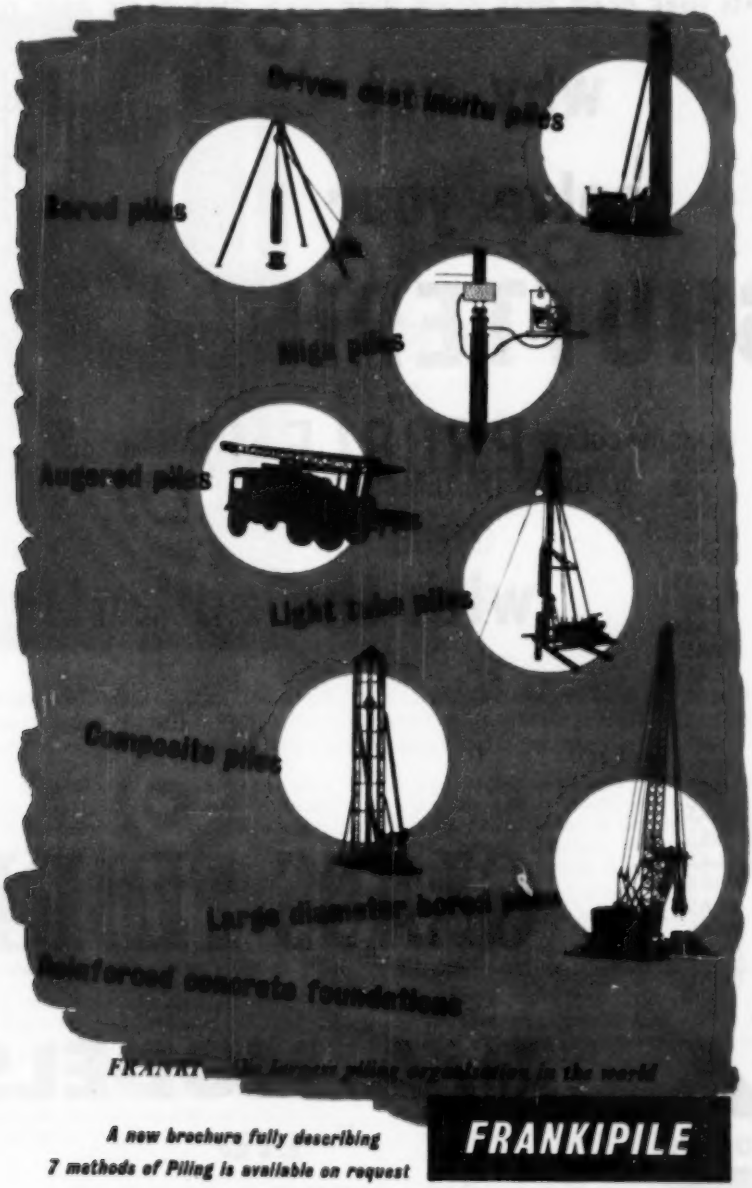

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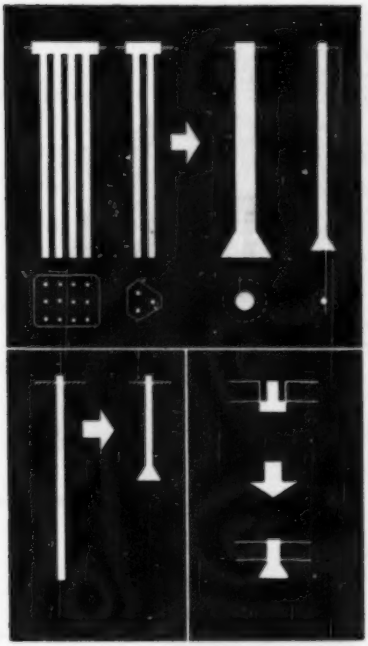

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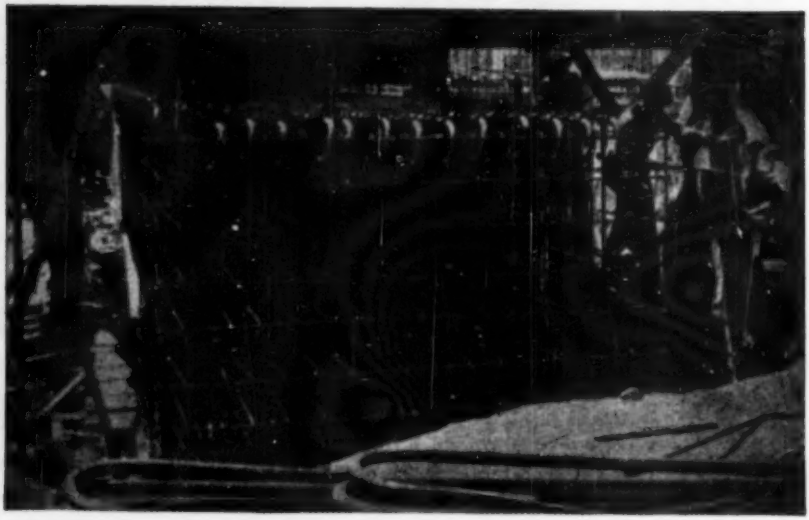

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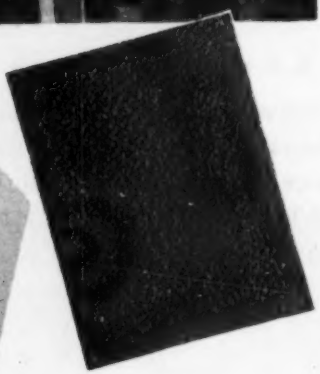

The water tower illustrated has a protective Stic B stone covering stipple finish similar to that shown in the smaller photograph. Treated in this way it is completely protected from the atmosphere and will require no further attention for many years. Stic B can be applied direct to new or old concrete and most other building surfaces. No other material affords such lasting protection, while remaining so easy to apply.

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New road bridge during construction on A.50 at Foston, Derbyshire, showing 40-ft. prestressed beams (pretensioned steel) designed to M.O.T. requirements. Main Contractors: D. T. Bullock & Co. Ltd., Aldridge, Staffs. By courtesy of the County Surveyor of Derbyshire—S. Mehew, Esq., O.B.E., B.Sc., M.I.C.E., A.M.T.P.I.

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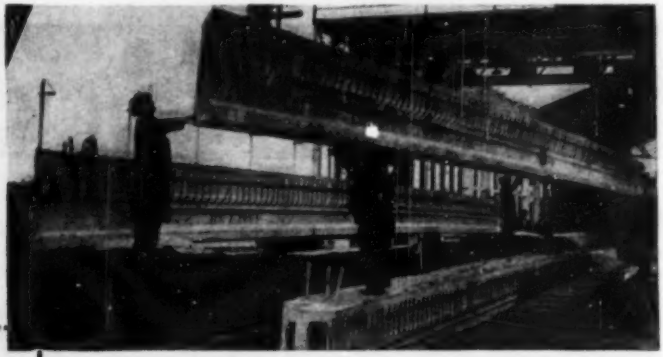

Illustration above shows some of the post-stressed bridge beams, each 80 ft. long and weighing 35 tons, produced by Anglian Building Products Ltd., for British Railways, Midland Region. Main Contractors: Messrs. Leonard Fairclough Ltd.

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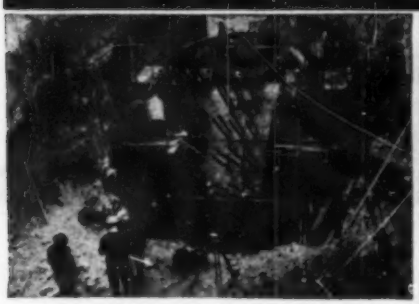
Forth Road Bridge Anchorages



Rylands were called on to provide a minimum breaking load of 350 tons for each unit and actual tests are as high as 381 tons.
The total weight of strand in these anchorages is about 630 tons.

Each anchorage is tunnelled 240 feet into the solid rock bed and filled with concrete. 278 steel tubes, 4½" diameter, are cast "in situ" and through these are threaded assemblages of four 1¼" diameter strands. Each assemblage is secured at one end by a massive zinc socket, the other ends being gripped for stressing by specially designed wedges.

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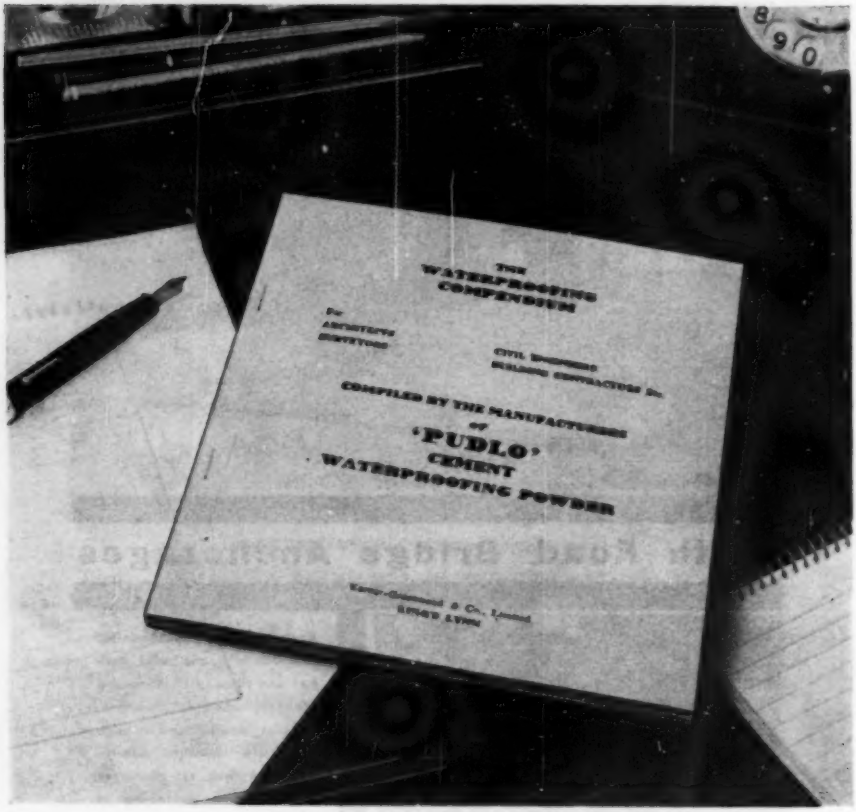

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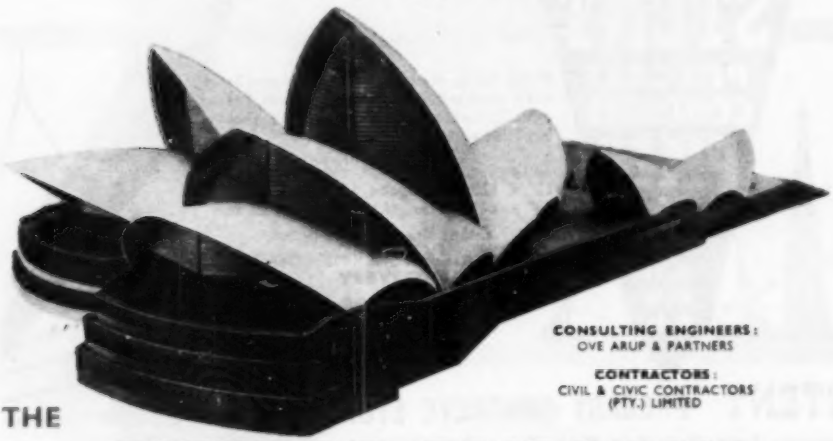

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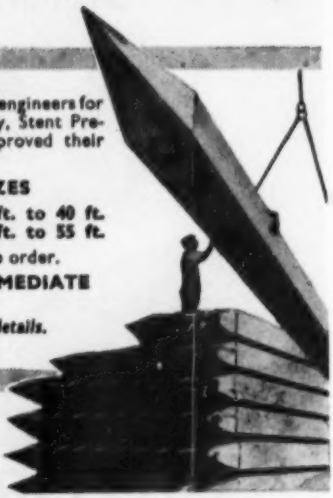

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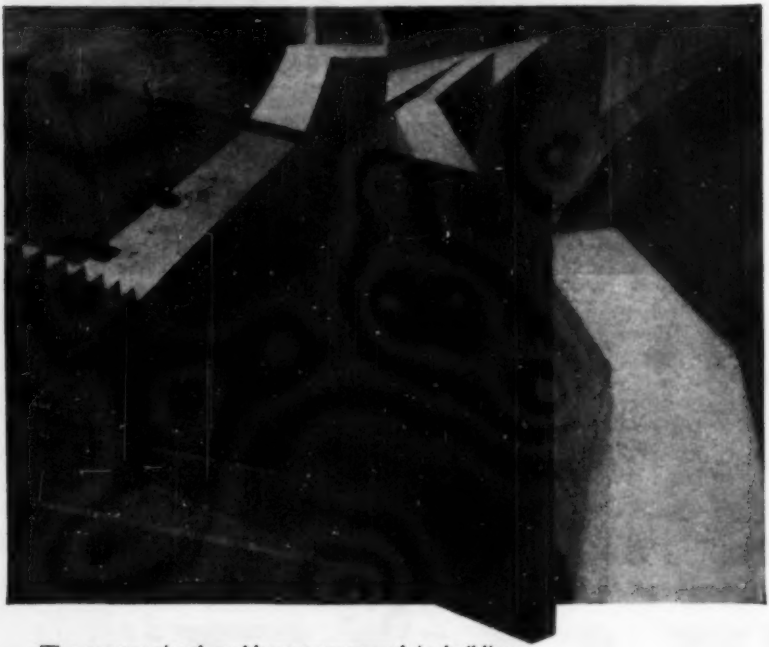

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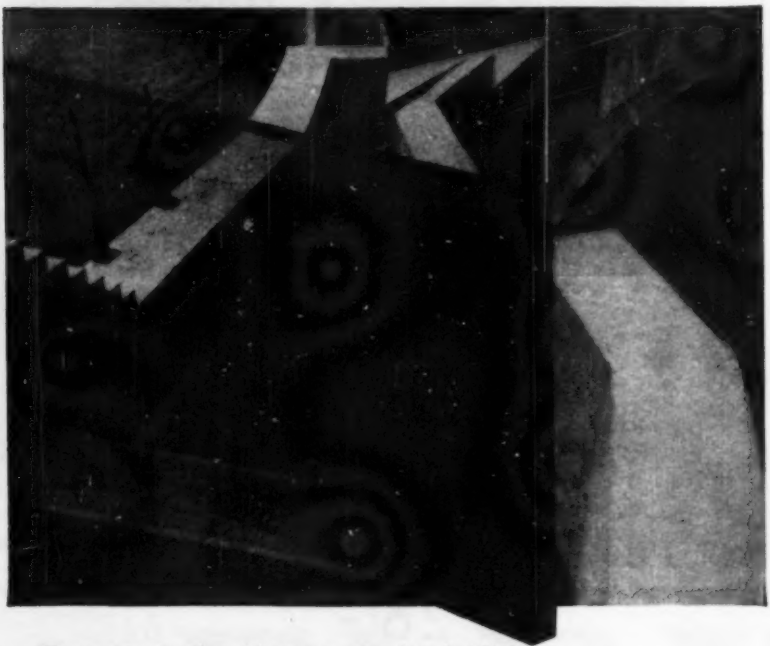

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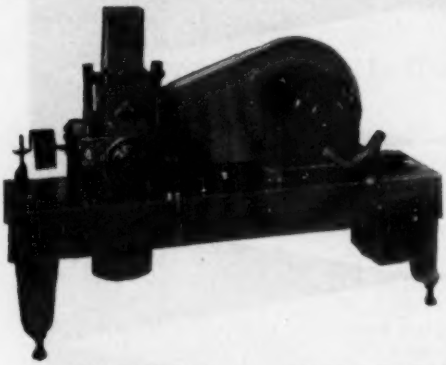

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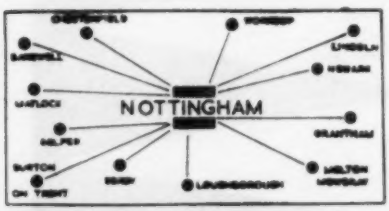

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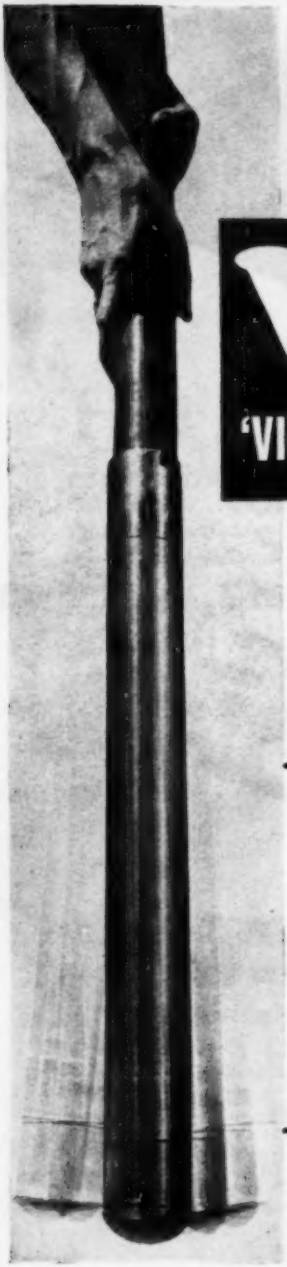

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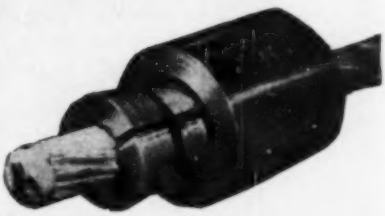

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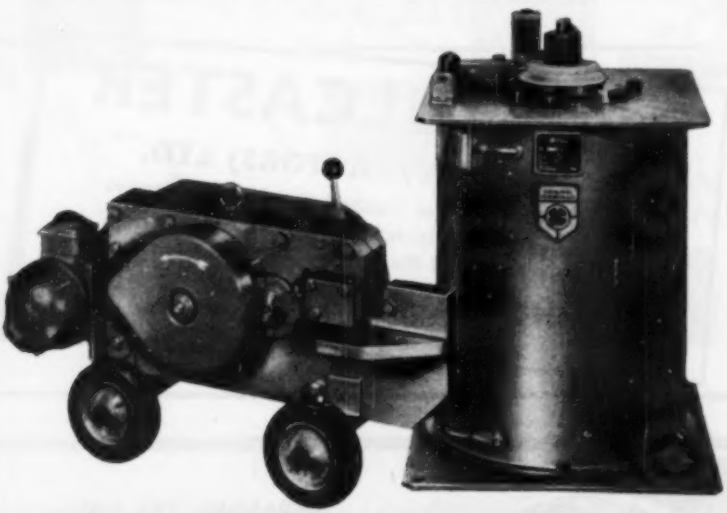

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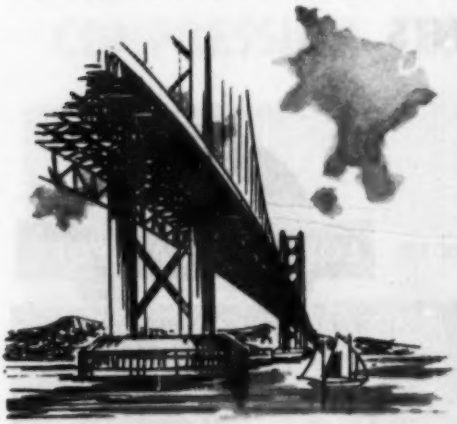

OVER * the Forth

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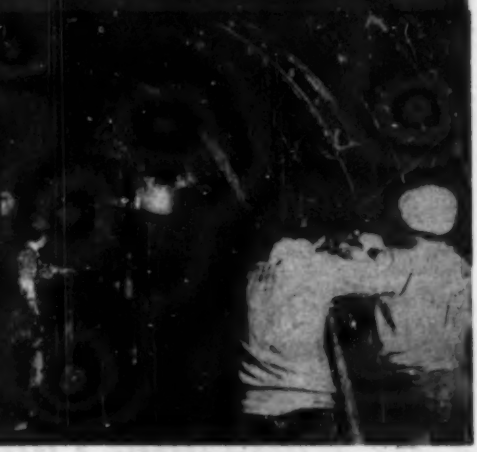

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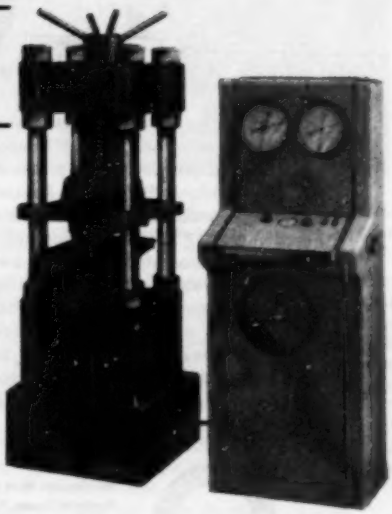

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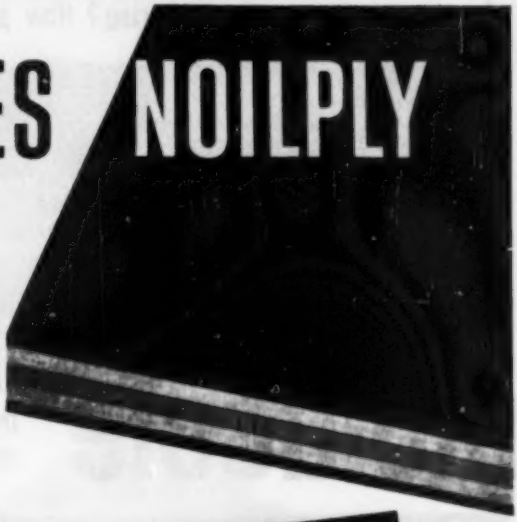

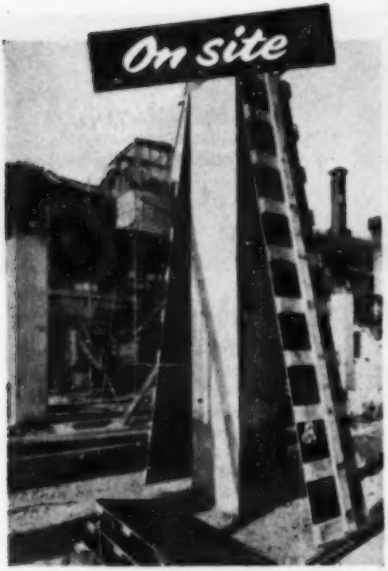

These 14 ft. columns for an office and wharehouse block in City Road, London, were poured in one lift. Photo by courtesy of the contractors: HIGGS & HILL LTD., London.

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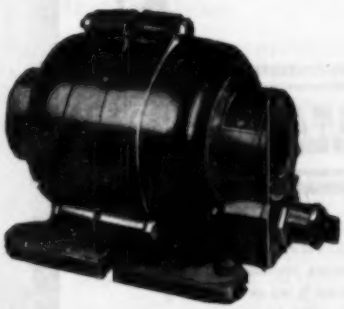

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CONCRETE
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CONSTRUCTIONAL ENGINEERING
INCLUDING PRESTRESSED CONCRETE

Volume LV, No. 11. LONDON, NOVEMBER, 1960.

EDITORIAL NOTES

The Metric System.

AT irregular, but not infrequent, intervals there are reawakenings of popular interest in the necessity or otherwise of adopting such proposals as simplified spelling, an international language, or reformed currency, weights and measures, or constructing a Channel Tunnel. The usual result seems to be that, after the initial resurgence, the interest flags without any definite conclusion being reached, let alone any action being taken to implement the proposals. It may not be unrewarding to speculate, therefore, whether there will be any definite outcome to the proposals given in a recent report * regarding the adoption in Great Britain of a decimal system of currency and the metric system of weights and measures. A change from the present system of weights and measures would affect considerably not only the public in general but the engineering and building industries in particular. The Report favours the adoption of the metric system in spite of the objections of some key engineering industries. The chairman of the committee which produced the Report supported the change when speaking at the annual meeting in September last of the British Association. He stated that "the metric system is the international language of science", but although this statement is true, it is by no means a common metrological system in industry throughout considerable parts of the world.

The metric system is in this country a legal alternative to the Imperial pound-inch system so long as no Act specifically requires a commodity to be sold in Imperial units. For example, sand and gravel, if sold by weight, can be in Imperial or metric tons but, if sold by volume, must be in cubic yards. Elsewhere in the world there is considerable variation. In most European countries and their present and former possessions, Latin America, and other states, the metric system is compulsory, and it is almost universal in the U.S.S.R. Metric, pound-inch, and idigenous systems are used in Egypt and Mexico, among other countries. In Finland the metric system is universal except in the timber and building industries in which British units are still common. Imperial units are used for some engineering products in Switzerland and Sweden, although the

* "Decimal Coinage and the Metric System: Should Britain Change?" A joint report of committees appointed by the British Association for the Advancement of Science and the Association of British Chambers of Commerce. (London: Butterworth's Scientific Publications. 1960. Price 7s. 6d.)

metric system is otherwise compulsory. India, Japan and Greece are taking action to enforce the metric system, and China, Sudan and some other countries are contemplating changing to the metric system. There remain nations, however, which in the aggregate represent an important fraction of the world's population and which adopt a pound-inch system; such nations include the Commonwealth (excluding India), the U.S.A., Eire, and Burma, although in the U.S.A., Canada, South Africa and Burma the metric system is permissible but rarely used except in science. Engineering equipment based on the pound-inch system is said to be more widely spread throughout the world than equipment based on the metric system and, the Report states, since there is no reason to regard metric standards as being inherently better than pound-inch standards, there is little inclination in Great Britain and the U.S.A. to change. It is clear, therefore, that a complete change to the metric system in Great Britain might not be wholly advantageous nor feasible in the dealings of this country with many others. Internally there would seem to be no great advantage in, or even a wish for, a change. The views of the engineering professions and constructional industries in Great Britain are of interest in this respect.

The Institution of Civil Engineers approves the change but visualises a problem in retraining staffs. The Institution of Structural Engineers considers that no change should be made unless the U.S.A. and Commonwealth do so; this proviso is also expressed by the Royal Institute of British Architects, which otherwise approves the change, with qualifications, and suggests that the adoption of an international modular system might be a solution. The Institute of Quantity Surveyors approves the change if allied professions and industries and the Commonwealth do likewise, although it is thought that the savings would not justify the cost and would prefer to rationalise the Imperial system. On the other hand, the Society of Engineers thinks the change would be an improvement and that we should not wait for the U.S.A. and the Commonwealth to conform.

Firms supplying building materials would in general approve the change, although some expect difficulty in retraining their older craftsmen. This difficulty is also foreseen by contractors, but these firms are largely dependent on architects, consulting engineers and others for the dimensional data of their works. British contractors who have worked on the Continent, and elsewhere, may be familiar with the metric system. The steel industry likewise is dependent on the dictates of its customers, apart from which approval of the change is dependent on co-lateral action by the U.S.A. and the Commonwealth. A maker of contractors' plant expects psychological opposition from the workmen with whom they are concerned.

Although principal land surveys are carried out in the metric system, the Ordnance Survey Office see no practical advantage, and some confusion, in adopting the system completely since most current maps relate miles to inches. The highway departments of the Ministry of Transport envisage some benefits but much technical data would have to be retabulated. The Ministry of Health and Local Government would also be faced with extensive revisions to by-laws, maps, standards and the like, and while not seeing any technical difficulty in making the change, is doubtful whether any benefit would eventually accrue. The tremendous amount of design data to be revised is also expressed by the administrators of the London Building Act. The United Kingdom Atomic Energy

Authority considers the change to be costly as regards its engineering departments since the metric system, which is used almost exclusively by its scientific staff, is not generally used by its engineers.

The views of staff and workmen are not recorded. It can be imagined that reinforced concrete designers should have little difficulty in dealing in metric units; in fact, many designers in this country are, or were, nationals of countries using the metric system. It is not too difficult to compute with working stresses of 70 kg. and 1400 kg. per square centimetre instead of 1000 lb. and 20,000 lb. per square inch. The metric sizes of reinforcing bars should not be too difficult to memorise. (A table of equivalent metric sizes and cross-sectional areas of round bars is given on page 424.) With workmen it may be different, but in some branches of constructional work there would be no difficulty. When measuring out the materials for concrete, the size of the measure or the setting of the scale of a weighing apparatus need only be determined once, and that by a competent person, and do not directly concern the operator. As regards shuttering, there again may be no difficulty because it is well known that the type of man attracted to carpentry is generally good at mensuration and therefore reasonably versatile where figures are concerned.

Even if it is granted that the mental effort associated with the change is not too great, that the cost is not prohibitive, and that the change could be made within a period of five to ten years, there remains the basic consideration of why should a change be made from the Imperial system, the use of which is so widespread. That the Imperial system could be vastly improved by deleting archaic measures and rationalising the remainder cannot be gainsaid, but there is much to be said for a system involving the prime factors two and three compared with one incorporating two and five. If a universal system is required, is the metric system the best? Exponents of the metric system will say that, even if it is not without defects, it is the best of the systems available and to devise a new system would only add to the confusion which the proposed change is attempting to alleviate. As the chairman of the committee stated at the meeting of the British Association, "there is an air of inevitability about the metric system. The public (and presumably engineers) would be well advised to educate itself and its children in this spreading and rational system."

Metric Sizes of Reinforcing Bars.

THE table on page 424 gives the following data relating to plain round reinforcing bars.

Diameters of bars in inches and the equivalent in millimetres.

Metric sizes of bars.

Cross-sectional areas of any number of bars up to ten in square inches and in square centimetres.

Book Reviews.

" Prestressed Concrete. Vol. II. Statically Indeterminate Structures." By Y. Guyon. (London: Contractors' Record, Ltd. 1960. Price 95s.)

THE second volume of M. Guyon's massive work on prestressed concrete contains about seven hundred pages and appears to be a collection of the author's numerous papers and notes on the subject of statically-indeterminate prestressed concrete structural systems such as beams and slabs and assemblies of beams as in portal frames and multiple-frame buildings. Cylindrical tanks, arches, domes and some other structures and foundations are not dealt with. The subjects are collated under two main headings, namely the elastic analysis of statically-indeterminate systems and tests.

The book is well printed and the diagrams are clear and instructive. The translator, Mr. C. van Amerougen, is to be commended for providing in the main a very clear exposition of what could be a difficult subject. All data are given in British units. There is some inconsistency as regards the symbols used, and in places contrary opinions are expressed. The absence of an index to such a vast mass of information may be deplored but the translator excuses this omission, and strikes the key-note of this work, when he states " M. Guyon's text calls for patient study, and the subjects dealt with, especially in the first half of the book, are so intimately related as to make any brief looking-up of individual items pointless." This book is not a work of easy reference.

" Railway Works Construction." By H. M. Pearson. (London: Odhams Press, Ltd. 1960. Price 35s.)

THIS book is intended for supervisors, foremen, and craftsmen engaged on civil engineering works on railways and deals with the subject in a practical manner starting from elementary arithmetic and drawing and the basic principles of structures, proceeding to consideration of materials and their behaviour in service, foundations, bridges, tunnels and buildings, and finishing with administration and the preparation of cost estimates and reports. Although some of the subject matter appertains to new works, consideration of the maintenance and repair of existing structures is prominent. Mining subsidence and other causes of defects are dealt with. The parts dealing with concrete are necessarily brief in a book of three hundred pages covering so many aspects of civil engineering. Space might have been well spent, however, to include a qualification of the stated ages at which concrete piles may be driven, and to enlarge on the subject of the cover of concrete over the reinforcement in view of the fact that on steam railways the atmosphere can be so deleterious to concrete. The section on prestressed concrete is too short to be useful.

" Der durchlaufende Bogenträger auf Elastischen Stützen mit und ohne Versteifungsträger." By W. Stampf. (Berlin: Springer-Verlag. 1960. Price 37.50 D.M.)

THE analysis of multiple-span arches on elastic supports with and without stiffening beams is given (in the German language). Because its application is limited, this type of structure is seldom dealt with in technical literature although it is frequently employed in industrial buildings. Under the action of dead load, such concrete arches and columns may be in compression throughout, thus providing a natural prestress to resist the effects of live loads and shrinking. Structures of this type can therefore be very long without requiring expansion joints. The calculations are based upon the deformation method in which the angle of rotation and the horizontal displacement are unknown. The structure is considered as a system of fully restrained arches and columns. The interacting bending moments and thrusts at the joints are expressed as functions of the unknown deformations at the joints.

Simplifications are introduced for symmetrical structures subjected to symmetrical loading. Intensive study is required to follow the equations which abound in cross-references which are unavoidable if the reasoning is to be understood. An approximate method of analysis is given for the case in which the shape of the arch and members can be expressed by formulæ. The results are within 25 per cent. of those obtained by more precise calculations.

The Resistance of Concrete Piles to Penetration.

A SIMPLE GRAPHICAL METHOD BASED ON THE STRESS-WAVE THEORY.

By DONOVAN H. LEE, B.Sc., M.I.C.E., M.I.Mech.E., M.I.Struct.E.

THE method of calculating the safe load on a pile driven by impact has for many years been a controversial subject, but recently more data from loading tests have become available for comparison. The calculation of the greatest load which a bearing pile will support should be based essentially on the physical properties of the strata below the bottom of the pile. The properties should preferably be obtained from tests of samples of the soil. The compressibility of the soil below the bottom of the pile is an important factor, particularly in the case of cohesive soils, the moisture content of which will be reduced, sometimes over a long period, by the increase of the pressure on the soil. Due to overlapping of the bulbs of pressure below the bottom of piles in a group the pressure on the soil below the piles may greatly exceed the pressure under an isolated pile, and it is necessary to know the properties of the soil at a depth equal to one and a half times the depth to which it is expected the piles will be driven, or even deeper if strata of soft cohesive soils are likely to occur within that part of the bulb of pressure in which the pressure on the soil is increased by 20 per cent. or more. A static formula should be used for estimating the necessary length and safe load of a pile, but for driven piles an impact formula may be used as a check and to ensure that each pile in a group has practically the same safe load and that the settlement is small and is practically equal for all the piles. If piles have to be driven when the condition of the ground cannot be known in advance or obtaining undisturbed samples of the soil is difficult or impossible, dependence must be placed on an impact formula from which the safe load is estimated from the resistance to penetration of the pile as measured by the set of the pile for one or more blows.

In the light of recent increased knowledge of this subject, the writer considers that most of the early formulæ should be disregarded. Hiley's formula,[1], [2] which has been extensively used in Great Britain and the Commonwealth, and with variations by Mr. J. S. Crandall[3] also in the U.S.A., is considered, in its original form, to give results too low for long piles. The Hiley formula estimates the resistance to penetration at the time of driving and not the ultimate static load, which is defined by Terzaghi as the least load causing a settlement equal to a tenth of the diameter (or width) of the pile. Therefore an allowance must be made for the reduction in the permissible load in the course of time if cohesive soils exist below the bottom of the pile. However, an addition can be made for the " take up ", or increase of resistance, if applicable, after driving has ceased. The same adjustments apply to the resistance to penetration if calculated by the stress-wave theory, but Bullen's formula[4] is related to the minimum static load causing permanent penetration, with a plasticity factor for use for piles in cohesive soil.

The stress-wave theory was first suggested for application to driven piles by Mr. D. V. Isaacs and subsequently was used by Dr. E. N. Fox in assisting

Dr. (now Sir William) Glanville[5] and others in determining the instantaneous stresses occurring in a concrete pile while being driven for comparison with piezo-electric recordings of the stresses in the pile. It was not suggested by Glanville and others that the resistance to penetration during driving could be deduced from the stresses. In subsequent research by Mr. E. A. Smith[6] it has been assumed that, if some allowance is made for damping, the theory is likely to lead to much better results than given by any impact formula.

Results obtained by E. A. Smith, based on the stress-wave theory, show generally greater resistance, particularly for long piles, than do Bullen's or Faber's formulæ apart from "take up" not included in Bullen's formula. The results obtained by the stress-wave theory show that the general form of resistance to penetration follows that of the older Wellington (or Engineering-News) formula, and does not conform to the results obtained from those formulæ which contain a term representing the efficiency of the blow, for example, the formulæ of Redtenbacher, Hiley, and Janbu. It is possible that the stress-wave theory can be adapted to give the resistance to penetration very closely, but it is necessary to make allowances, which may sometimes be considerable, for the reduction in ultimate static load where the pile is in cohesive soil or where cohesive soil exists at a lower level but still within the bulb of pressure. Pending further experience, it is probable that, for concrete piles, the results obtained by the stress-wave theory, as currently presented, will exceed the resistance to penetration due to a static load being applied for a short time, and by a greater amount for a permanent load, on piles bearing on strata of cohesive soils depending on the increase in the pressure on the subsoil and the properties of the soil. E. A. Smith has applied a damping factor, and Dr. D. E. Jenkins, in assisting the writer, has found that an allowance for the inertia of the pile will account for a reduction of 30 per cent. to obtain the static resistance to penetration. This factor is used in the following.

Notation.

A, Cross-sectional area of pile.
b, Breadth of pile.
C_1, Temporary compression of the dolly and head packing.
C_2, Temporary compression of the pile.
C_3, Temporary elastic compression of the ground.
d, Depth or side of the pile.
E_c, Modulus of elasticity of the concrete.
e, Equivalent elastic set.
h, Effective free fall of hammer.
h_1, Effective free fall of hammer allowing for inertia of the helmet.
h_r, Fall of hammer on pile driven to refusal.
l, Length of pile.
M, Weight of hammer.
m, Weight of helmet.
R, Resistance to penetration (static load).
s, Set per blow.
W, Total weight of pile.
w, Weight of pile per foot.

Application of the Stress-wave Theory.

Since the determination of the resistance to penetration by the stress-wave theory is too laborious for general use, the following method, developed by the

writer, may be applied to concrete piles more than 35 ft. long. The method, which has been adapted from the work of Glanville, is based on the need to limit the greatest stress at the top and bottom of the pile so that the pile will not be damaged. An instantaneous maximum stress of 2500 lb. per square inch has been used by the writer as the desirable instantaneous stress for concrete having a cube-strength of 5000 lb. per square inch, and should provide a reasonable factor of safety.

The determination of the fall or drop of the hammer and the stiffness of the packing on the top of the pile, which factors control the stress at the top, and the least equivalent elastic set, which controls the stress at the bottom of the pile, can be achieved in one graphical operation by use of the accompanying chart.

E. A. Smith has shown that the reduction of stress in the length of the pile by propagation, apart from friction on the side, is almost negligible, so that the approximate resistance to penetration, including the friction on the side, is given by the area of the cross-section of the pile multiplied by the stress of 2500 lb. per square inch at the top multiplied by a factor to allow for the inertia of the pile. It is usual to include the friction on the side with the bearing resistance under the foot of the pile, and the friction tends to be increased by the " take-up " on cessation of driving. However, in the case of a pile in filling which may settle in course of time, the resistance to penetration will decrease because the settling of the ground around the pile tends to drag the pile downwards by the friction acting in the reverse direction.

The stress-wave theory emphasises the importance of the stiffness of the packing, or cushion, under the helmet on the top of the pile. Typical values of the stiffness of various types of packing are given in *Table* I.

TABLE I.—STIFFNESS VALUES (APPROXIMATE) OF TYPICAL HEAD PACKINGS.
(lb. per square inch per inch)

Head packing (or cushion)	lb. per square inch	
	after 25 blows	after 2000 blows
2-in. felt	7700	17,200
3-in. coiled hemp rope	8300	12,100
2-in. sacking	9600	15,000
3-in. asbestos fibre	7900	8,300
4-in. softwood	3000*	32,000*

NOTES.—The thickness is measured under the static weight of the hammer after 25 blows.

* Subject to wide variation.

It is necessary to make allowance for the effect of the helmet on the impact when determining the effective free fall h_1 of the hammer as given by

$$h_1 = \left(\frac{M}{M+m}\right)^2 h.$$

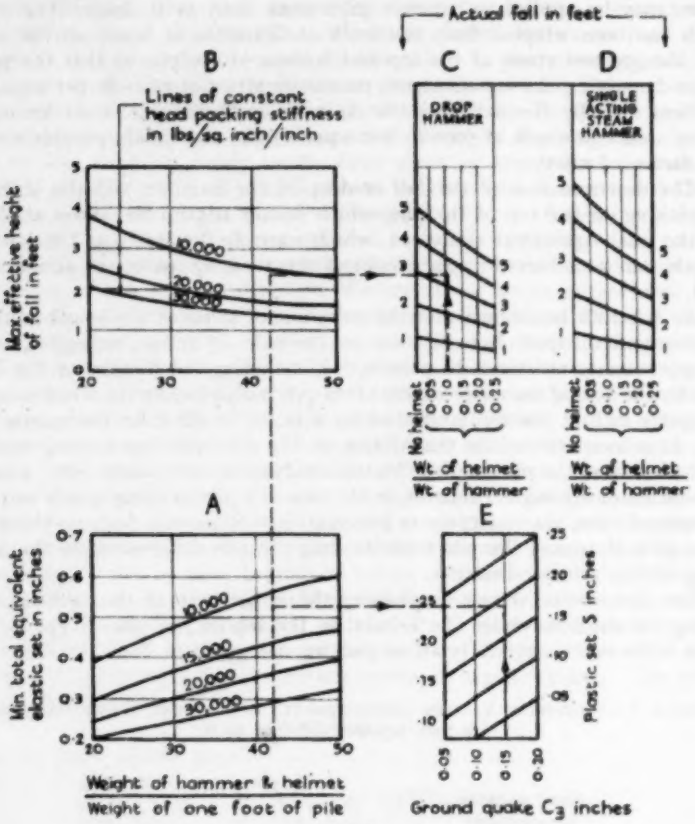

Fig. 1.

In addition to the effect of the helmet and the ratio of the weight of the hammer and helmet, the effective free fall of a drop-hammer is about 80 per cent. of the actual fall and that of a steam-hammer about 90 per cent. Either reduction factor can readily be taken into account, by reading from the appropriate scale, when using the charts in *Fig.* 1.

It should be noted that with the stress-wave method, as with Hiley's formu'a, the quake of the soil should be measured or an estimate of the amount must be made. If the quake cannot be determined accurately, a reasonable dimension for C_3 is 0·1 in. and it may be seen, by reference to data compiled by Bullen, that this will possibly exceed the actual amount and the results may therefore be slightly conservative. It is important to note that the equivalent elastic set, as used by Dr. Glanville, is (twice the actual plastic set) plus (the quake or elastic set of the soil); therefore $e = 2s + C_3$.

The application of the chart is shown in the example which follows.

Example.—Determine (a) the greatest allowable free fall of a 4½-ton drop-hammer, (b) the least final actual (plastic) set, and (c) the resistance to penetration of a 16-in. square reinforced concrete pile 70 ft. long. The maximum allowable stress during driving is 2500 lb. per square inch, the weight of the helmet is 10 cwt., the packing on the head comprises 2 in. of compressed sacking, and assume that the quake of the ground has been determined to be 0·15 in.

The weight of the pile is $\frac{16 \times 16 \times 150}{144} = 267$ lb. per foot.

The ratio $\frac{\text{weight of helmet}}{\text{weight of hammer}} = \frac{m}{M} = \frac{0{\cdot}5}{4{\cdot}5} = 0{\cdot}11.$

The ratio $\frac{\text{weight of hammer and helmet}}{\text{weight of pile per foot}} = \frac{M+m}{w} = \frac{5 \times 2240}{267} = 42.$

Assume the stiffness of 2 in. of compressed sacking is 11,000 lb. per square inch per inch after about 500 blows (see *Table* I).

Referring to *Fig.* 1, from charts B and C, the greatest allowable free fall is 3 ft. 6 in. Also from charts A and E, the least plastic set for a quake of 0·15 in. is 0·19 in., that is approximately five blows per inch of penetration. The greatest force that may be applied at the top of the pile is $\frac{2500 \times 16^2}{2240} = 286$ tons, which represents a measure of the total resistance to penetration (including side friction if any). When allowance is made for the inertia force accelerating the pile, say 30 per cent., the resistance to penetration is given approximately by $R = 0{\cdot}7 \times 286 = 200$ tons.

The charts in *Fig.* 1 may, of course, be used to determine any two of the four data, that is the weight of hammer, distance of free fall, the least stiffness of packing required, and the set, provided the other two terms are known.

Since the chart is based on driving to obtain a stress of 2500 lb. per square inch, it cannot be readily adapted to apply to piles driven with smaller stresses, but it is useful to safeguard against greater stresses occurring which may needlessly damage the pile.

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4.—"A New Calculation for the Bearing Capacity of Driven Piles." By F. R. Bullen. Proc. Inst. Civil Eng. May 1959.

5.—"An Investigation of the Stresses in Reinforced Concrete Piles During Driving." By W. H. Glanville, G. Grime, E. N. Fox, and W. W. Davies. Building Research Technical Paper No. 20. 1938.

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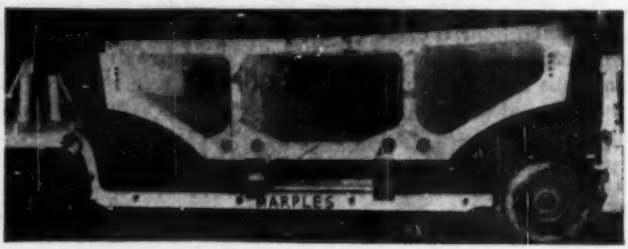
"Concrete and Constructional Engineering" Prize Design.

A PRIZE is awarded each year by the proprietors of this journal for competition amongst the students at the Course on Concrete Technology at Imperial College, University of London. The problem, which was set for the session 1959-60 by Professor A. L. L. Baker, D.Sc., M.I.C.E., was to plan a small port on an imaginary site and to design one or more structures suitable for such a development. The structures were to include berthing accommodation for vessels of various sizes, single-story factories, multiple-story offices, hotels and flats, a road bridge over a river and subsidiary bridges, a railway station, swimming bath, and ancillary structures.

About fifty entries were submitted, several of which displayed a good grasp of the application of engineering principles as well as a practical knowledge of details, especially in the case of some of the designs of the bridges, multiple-story buildings and the covered swimming bath. Much care and labour had been expended on the calculations, particularly for the designs of shell roofs. The design selected as the best in most respects was that of a prestressed concrete bridge submitted by MR. S. TALAPATRA, although there were two or three designs of similar structures of almost equal merit. The selected design, for which the entrant receives the prize of £25, is for a five-span prestressed concrete continuous-girder road bridge, the spans being two of 150 ft., two of 220 ft., and a central span of 300 ft. The designs next in order of merit were those submitted by Mr. P. R. Dhar and Mr. B. H. Webb.

Elevated Road at Hammersmith.



THE construction of the elevated road ½-mile long at Hammersmith, the design of which was described in this journal for November 1959 and, in more detail, August 1960, has now commenced. The approach ramps are well in hand. Some of the precast components of the double-cantilevered elevated road have also been made, and the illustration shows one of the precast beam units being transported to the site. The units for the prestressed concrete superstructure are being cast by the contractors, Messrs. Marples, Ridgway & Partners, at a yard at Heston.

Glen Nevis Hydro-electric Scheme.

THE scheme prepared by the North of Scotland Hydro-Electric Board in connection with harnessing the water power in Glen Nevis, is estimated to cost £4,200,000 and to take four years to complete. The works will include an arch dam about 240 ft. high, from which the water will be conducted in a tunnel to an underground power station of about 25,000 kilowatts capacity.

The Construction of the Medway Bridge near Maidstone.

THE method of construction of the bridge to carry the Maidstone by-pass road over the River Medway was controlled by the requirement that no supports should be placed in the river. Therefore the beams for the river span were precast and moved over a temporary bridge to their final positions. The design of the permanent structure was described in this journal for December 1959.

The four beams of the suspended span are over 80 ft. long and each weighs about 165 tons. They were precast on the western bank about 100 yd. from the river. Each beam was precast in shuttering resting on rail-tracks of greater length than the beam and was prestressed with post-tensioned twelve-wire cables. Temporary steel I-beams were bolted to the upper surface of each beam and extended beneath 6-in. steel bars placed through inverted U-bars which project from the upper surface of each beam near the ends (*Fig.* 1). The I-beams project beyond the ends of the beam to provide means of raising and lowering the beam by jacks.

Fig. 1.

Erecting the River Span.

When the cantilevers on each side of the river were complete, it was possible to move the first precast beam into position. Pairs of steel beams were placed at the ends of three adjacent cantilevers at each side of the river, each steel beam spanning 15 ft. between the ends of adjacent cantilevers. The steel beams supported two steel lattice girders which spanned the river and were placed one on each side of the line of one inner main concrete beam (*Fig.* 4). The lattice girders were each formed of five Bailey trusses placed side by side and were "launched" over the river in the usual way. Narrow-gauge rail-tracks were laid along the top boom of each lattice girder and a gantry was assembled to span between bogies of 50 ton capacity running on the tracks (*Fig.* 3). The gantry is formed of four Bailey trusses placed side by side.

When a beam was required for placing, a rail-track extending from the bridge was connected to the length of track on which the beam rests. A bogie was pushed into position under the temporary steel I-beams at the ends of the beam, and the weight of the concrete beam was transferred to the bogies by hydraulic jacks (*Fig.* 2). The shuttering for the bottom of the beam was then removed and the beam was ready to be moved down the inclined track to the bridge. The progress of the beam was controlled by means of winches on each bank of the river.

The first precast beam was moved down to the end of the western cantilever where the weight of the beam was transferred from the leading bogie to timber packing on the end of the cantilever between the two lattice girders. The gantry was used to transport the empty bogie across the river to rail-tracks laid on the eastern cantilever.

The gantry was then moved back across the river to support the leading end of the precast beam (*Fig.* 4) by means of

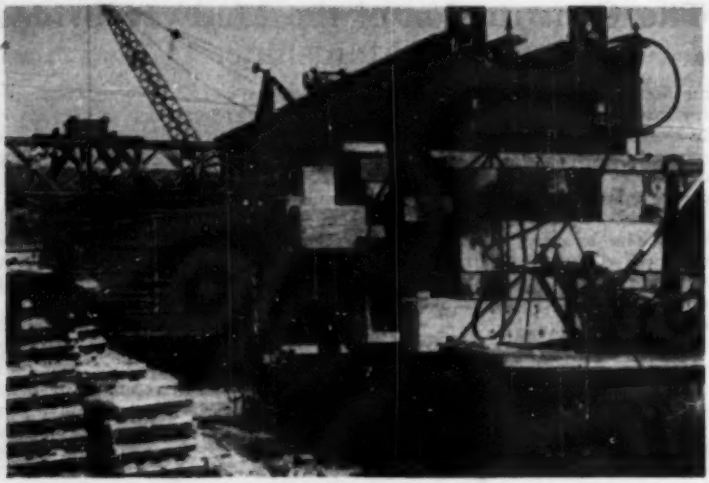


Fig. 2.

steel hangers and 6-in. steel shearing pins. The packing beneath the river end of the precast beam was removed and the beam drawn across the gap by means of winches. The beam was then lowered on hydraulic jacks until the projecting steel beams were supported on timber packing at the end of the eastern cantilever. The gantry was then returned to the western side to support that end of the precast beam while the bogie was removed and replaced by timber packing. The beam was then about 6 ft. above its final position and was lowered gradually by means of hydraulic jacks. While this operation was proceeding the lattice girders were dismantled and removed. The time taken to move the precast beam to its position across the gap was about two hours. Although the timber packing under the beam was mainly hardwood, the weight of the beam was sufficient to

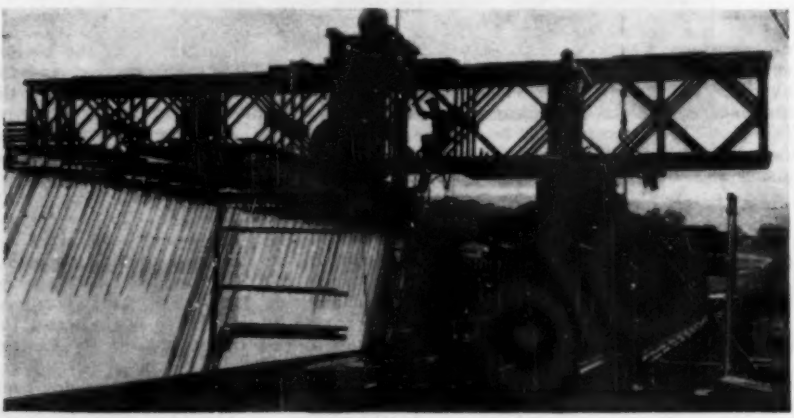


Fig. 3.

compress the 6 ft. of packing by about 3 in., reducing the effective extension of the jacks from 6 in. to 3 in. while lowering the beam.

When the first precast beam was in its final position the projecting U-bars were cut off and the beam provided a permanent bridge for the transportation of the other three precast beams on rail-tracks laid on this beam. The second and succeeding beams were each transported on bogies to a position above the first beam and rested on the first beam while tracks were laid on steel beams between the ends of adjacent cantilevers. The ends of the beams were then supported on bogies on these transverse tracks and the beams moved to a position over their final seatings. The beams were lowered into their final positions in the same way as the first beam.

The End Spans.

The beams for the eastern span are similar to those of the river span except for the bearing at the eastern end. These beams and those for the western span were precast in shuttering supported by timber props resting on the ground. When the concrete had hardened the beams were prestressed and lowered into

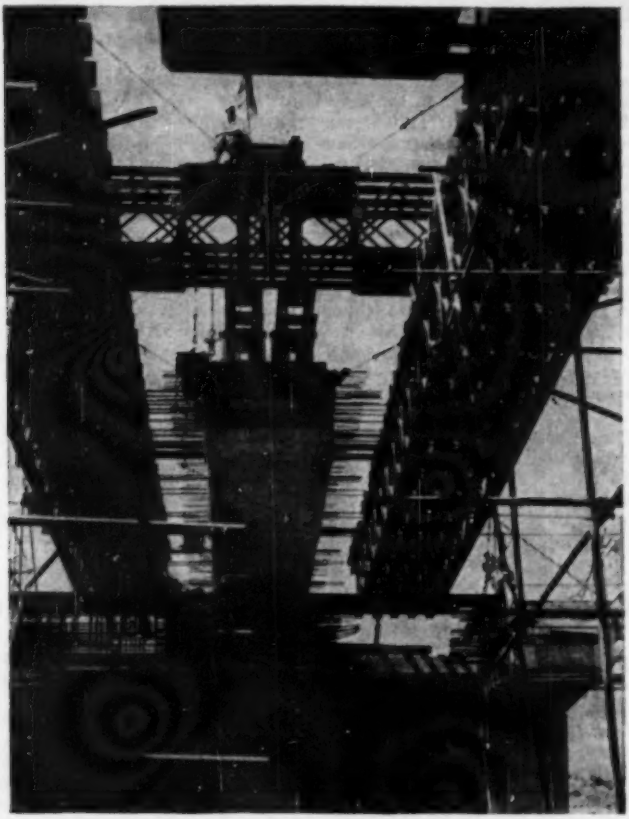


Fig. 4.

Fig. 5.

their final position by means of temporary steel beams and jacks in the same way as the suspended span. When the beams were in position the projecting U-bars were cut off.

The materials for the part of the bridge on the eastern bank were placed by means of a 15-ton derrick to the south of the bridge. A temporary Bailey bridge was erected to provide access for vehicles and staff.

Because it was required that there should be no supports in the river, the balanced cantilever on the eastern bank was concreted in shuttering projecting over the river and supported as shown in *Fig.* 5.

The concrete was mixed in a 1-cu. yd. mixer at a batching plant on the western side of the river. The concrete for the precast members was mixed in the proportions of 1 to 3·1 by weight, using aggregate having a maximum size of ¾ in.; the crushing strength required was at least 7000 lb. per square inch at twenty-eight days. The water-cement ratio was 0·38 and the slump about 2 in. The concrete for the reinforced piers and abutments had a crushing strength of at least 4500 lb. per square inch at twenty-eight days.

Between the river and the batching, mixing and precasting area, there is a railway which is roughly parallel to the river and over which a prestressed concrete bridge has been constructed to carry the new road. The large precast beams passed over this bridge on their way to the river bridge.

The bridge is being constructed for the Ministry of Transport. The design was prepared by Messrs. Scott & Wilson, Kirkpatrick & Partners, who are also supervising the construction. The contractors are Sir Robert McAlpine & Sons, Ltd.

Reckoners for Guaranteed Minimum Time.

PART II of British Standard No. 1151, "Guaranteed Minimum Reckoners for the Building and Civil Engineering Industries" (obtainable from the British Standards Institute, price 5s.), was published recently. The standard gives a formula for calculating the appropriate guaranteed minimum payment due to an operative when the number of working hours available to him is less than the normal hours as laid down in the Working Rule Agreement. Four tables of ready reckoners enable the actual proportions to be seen at a glance. Allowance is made for the changes in the length of the working week which now operate in the building and civil engineering industries.

Chimneys 550 ft. High in Britain.

THE two chimneys, each 550 ft. high, which are to be built at Blyth "B" Power Station, Northumberland, will, it is believed, be the tallest reinforced concrete chimneys of large diameter in the country. One of the structures will have an internal diameter of 27 ft. at the top and the other 30 ft. Both chimneys will be lined with brick. The estimated cost is £153,000. The consulting engineers to the Central Electricity Board are Messrs. Merz & McLellan. The Contractors are The Mitchell Construction Co., Ltd.

Design of Biaxially-loaded Columns by the Ultimate-load Method.—II.*

By F. N. PANNELL, M.Sc.Tech., B.Sc.(Eng.), A.M.I.C.E., A.M.I.Struct.E.

Columns with Eight or Four Bars.

THE theory for multiple-bar columns described in Part I of this article is applicable with almost equal accuracy to columns with eight or four reinforcing bars. In each case it is necessary to apply the equations of static equilibrium relating to the particular arrangement of reinforcement. The equations for columns with eight reinforcing bars are given in Appendix II and are the basis of the charts in *Figs.* 5 to 8. The equations for columns with four bars are given in Appendix III and are the basis of the charts in *Figs.* 9 to 12. In the case of columns with eight or four bars the theoretical load causing failure is predictable by means of these curves with an accuracy generally within 1 per cent.; in a few cases the error may be 2 per cent.

The charts are valid for any radial eccentricity of load and can therefore be applied to columns subjected to bending about one major axis only. The area of reinforcement obtained from the charts for four-bar columns can be distributed as desired near opposite faces of the column, but the arrangement of reinforcement for columns with eight or more bars should not be altered.

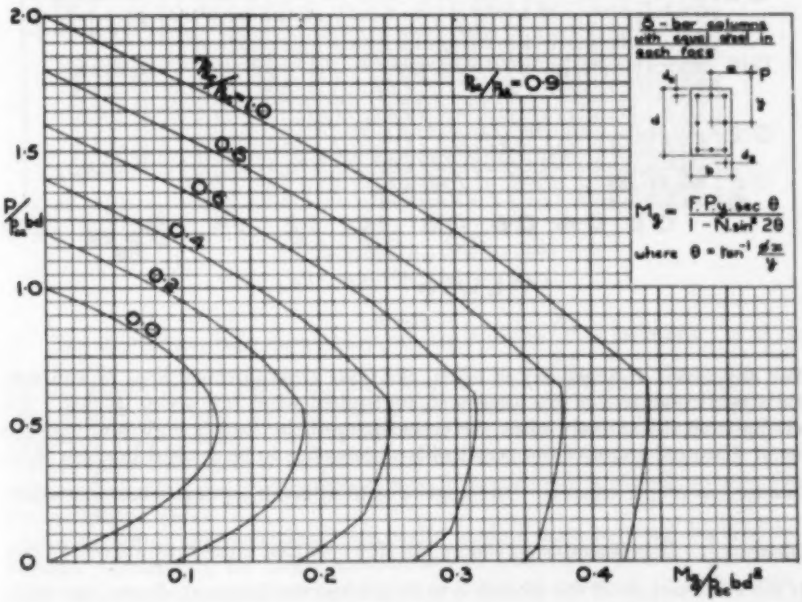


Fig. 5.

* Continued from October, 1960.

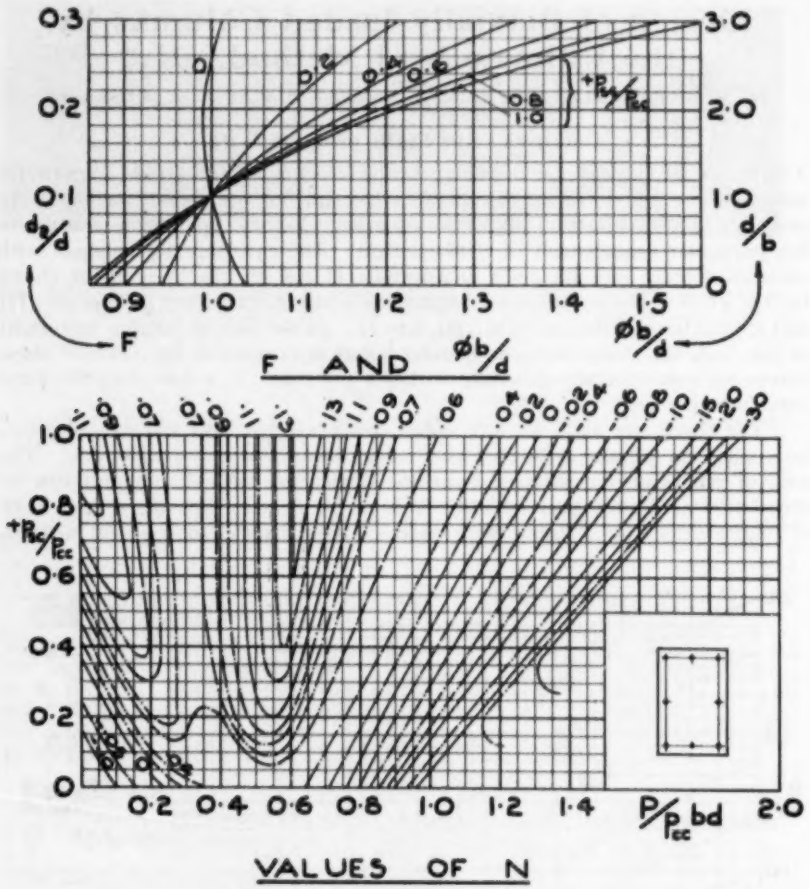


Fig. 6.

For any given arrangement of loads, the least cross-sectional area of concrete, for a particular area of reinforcement, is required when θ is about 45 deg. The saving is significant only when the eccentricity of the load is high, and may not occur when reduction of the permissible stresses has to be applied because of the slenderness of the column. The angle θ will be about 45 deg. when $\frac{b}{d}$ is nearly equal to $\frac{x}{y}$. It is desirable to choose the side b so that θ does not exceed 65 deg. If the cross-section of the column is sketched and the diagonals drawn, the side b should form the base of the triangle containing the point of application of the load, in which case θ will not greatly exceed 45 deg.

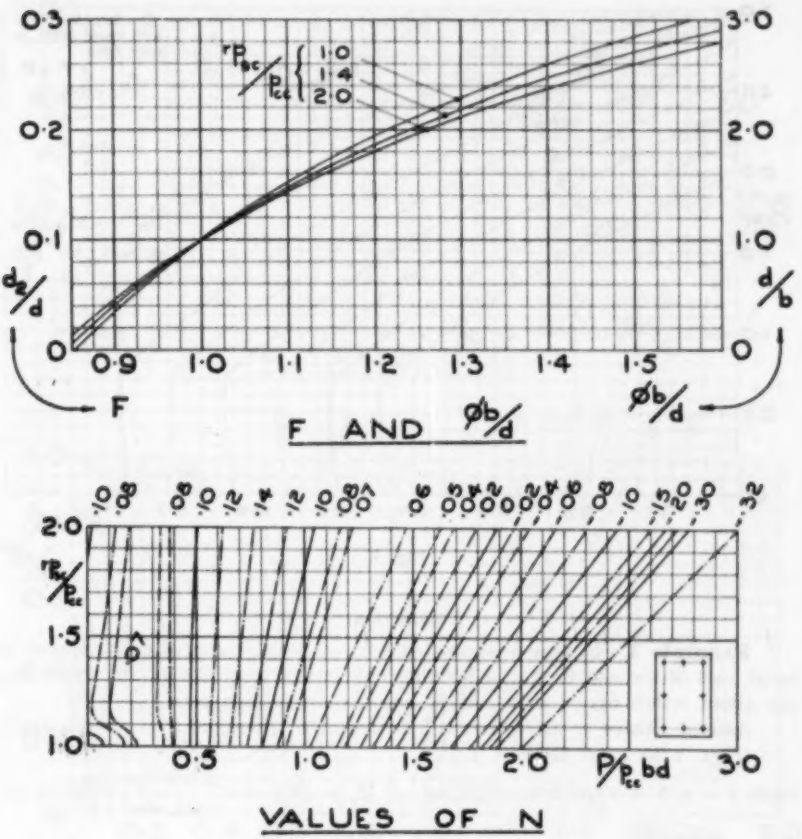


Fig. 7.

The charts have been derived for the case in which $\frac{p_{sc}}{p_{st}} = 0{\cdot}9$ and $p_{sc} = 18{,}000$ lb. per square inch. However, they may be used when $p_{sc} = 16{,}000$ lb. per square inch, in which case the size of the column will be slightly larger than necessary. The greatest effect of this reduction of the permissible stress in the steel is taken into account in the charts, but the stress in any bars still in the elastic range when the load causing failure is applied will be slightly greater than the estimated value.

A saving in reinforcement is generally made if four bars can be used in a column, particularly for large eccentricities of load. If, however, the column and bars are large, the increased cover of concrete required, together with a reduction of permissible stress for bars of 1½-in. diameter and larger, may outweigh any advantage, as is illustrated in Example No. 5.

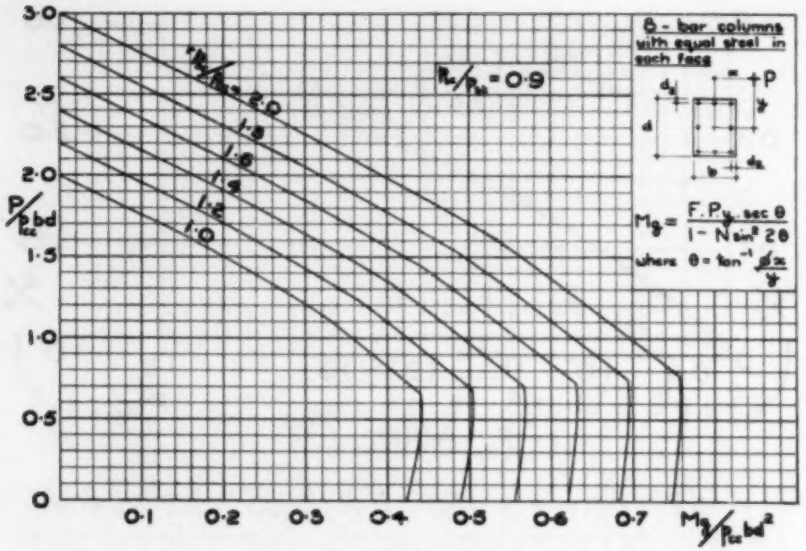


Fig. 8.

Examples.

Example 3.—Design a square column of 1 : 2 : 4 concrete to support an axial load of 100,000 lb. and a bending moment of 2,000,000 in.-lb. which may act about either major axis. Allow 2½-in. cover of concrete.

Assume twelve or more bars will be required; therefore *Figs.* 1 to 4 apply. (*Figs.* 1 to 4 are in Part I.)

Since $x = 0$, $\theta = 0$ and from equation (a), $M_g = FPy$; $e = \frac{2{,}000{,}000}{100{,}000} = 20$ in. and $\frac{\sqrt{P}}{e} = \frac{\sqrt{100{,}000}}{20} = 15{\cdot}8$; since this value is less than 30, choose a size of column such that $\frac{M}{f_{cc}bd^2} = 0{\cdot}325$ (see notes for *Table* I), that is $d = \sqrt[3]{\frac{2{,}000{,}000}{760 \times 0{\cdot}325}} = 20{\cdot}1$ in., say 20 in. square. $\frac{P}{f_{cc}bd} = 0{\cdot}329$ and from *Table* I, $r\frac{f_{sc}}{f_{cc}}$ is about 0·65. Since $\frac{d_2}{d} = \frac{3}{20}$, from *Fig.* 1, $F = 1{\cdot}07$. Then $M_g = 1{\cdot}07 \times 2{,}000{,}000 = 2{,}140{,}000$ in.-lb. and $\frac{M_g}{f_{cc}bd^2} = 0{\cdot}352$. From *Fig.* 2, $r\frac{f_{sc}}{f_{cc}} = 0{\cdot}75$. The area of reinforcement required is therefore $\frac{0{\cdot}75 \times 760 \times 400}{18{,}000}$ sq. in. = 12·60 sq. in., say sixteen 1-in. bars.

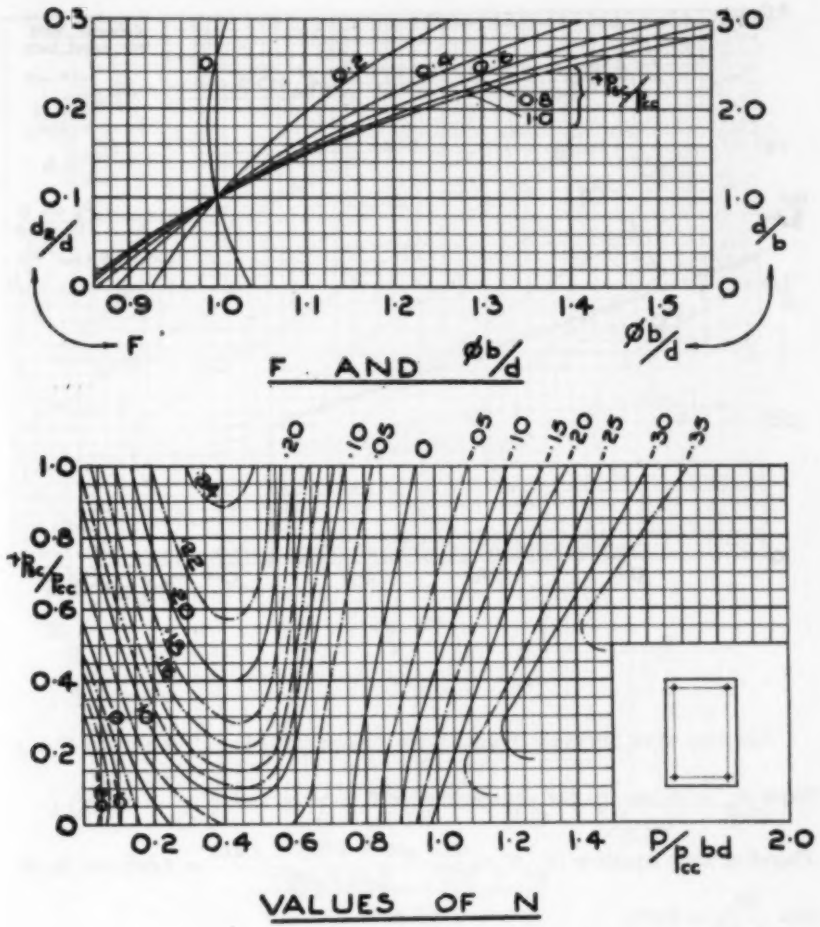


Fig. 9.

Example 4.—Compare two columns of 1 : 2 : 4 concrete each 20 in. square having equal areas of reinforcement equally distributed near each side, one column having sixteen 1-in. bars and the other four 2-in. bars. Each column is subjected to an axial load of 400,000 lb. and bending moments of 735,000 in.-lb. acting about the X and Y axes simultaneously.

In each column $r = 3{\cdot}14$ per cent., $p_{cc}bd = 304{,}000$ lb., $\frac{d}{b} = 1$ and $\frac{P}{p_{cc}bd} = 1{\cdot}315$; $x = y = 1{\cdot}835$ in., $\phi = 1$, $\theta = 45$ deg., sec. $\theta = 1{\cdot}414$, and $\sin^2 2\theta = 1$.

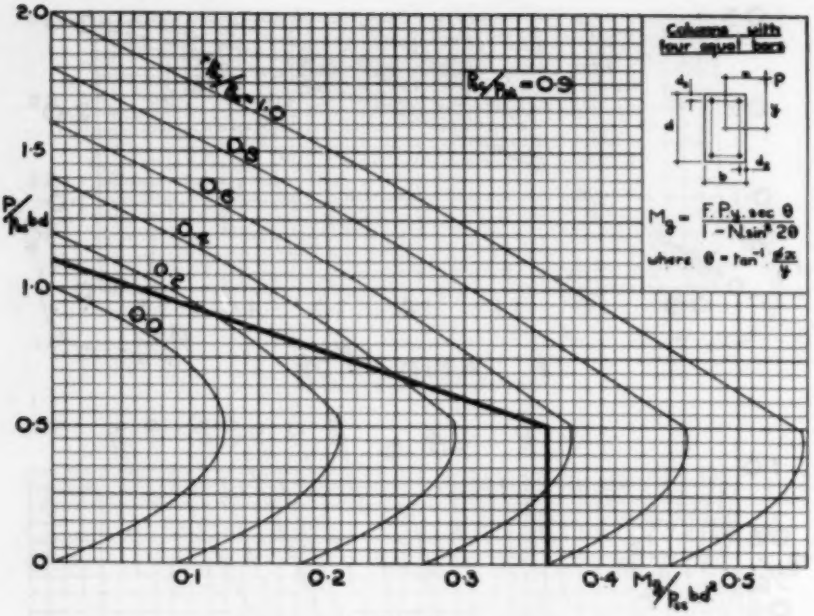


Fig. 10.

Column with Sixteen Bars.—With a cover of 1½ in., $\frac{d_2}{d} = 0{\cdot}1$ and $F = 1$.

Since $p_{sc} = 18{,}000$ lb. per square inch, $r\frac{p_{sc}}{p_{cc}} = 0{\cdot}745$ and $N = -0{\cdot}033$.

Therefore from equation (1), $M_g = \frac{1 \times 400 \times 1{\cdot}835 \times 1{\cdot}414}{1 + 0{\cdot}033} = 1{,}005{,}000$ in.-lb.,

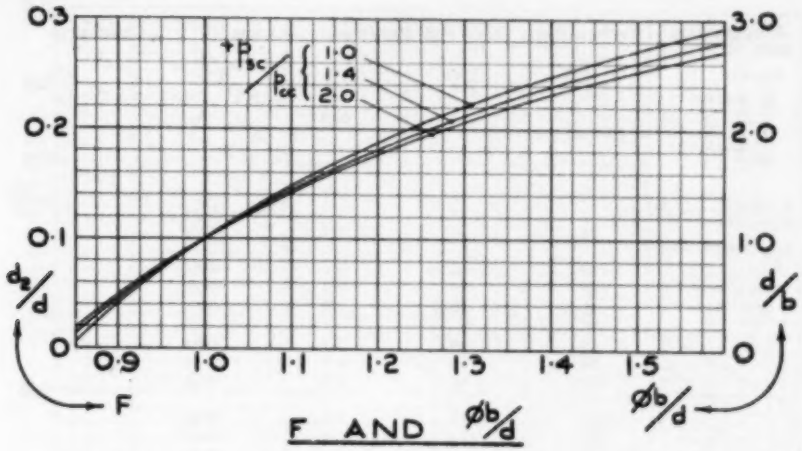
and $\frac{M_g}{p_{cc}bd^2} = 0{\cdot}165$.

Since $\frac{P}{p_{cc}bd} = 1{\cdot}315$, the required value of $r\frac{p_{sc}}{p_{cc}}$, from *Fig.* 2, is 0·745 and the column is satisfactory.

Column with Four Bars.—For bars of 2 in. diameter, 2-in. cover of concrete is required, hence $\frac{d_2}{d} = 0{\cdot}15$ and $F = 1{\cdot}096$.

Since $p_{sc} = 16{,}000$ lb. per square inch, $r\frac{p_{sc}}{p_{cc}} = 0{\cdot}662$ and $N = -0{\cdot}24$.

Therefore $\frac{M_g}{p_{cc}bd^2} = \frac{1{\cdot}096 \times 735 \times 1{\cdot}414}{304 \times 20(1 + 0{\cdot}204)} = 0{\cdot}151$.



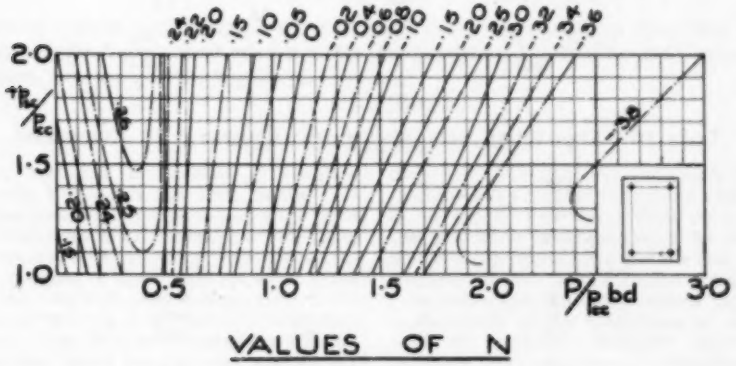


Fig. 11.

Since $\frac{P}{p_{cc}bd} = 1{\cdot}315$, the required value of $r\frac{p_{sc}}{p_{cc}}$, from *Fig.* 10, is 0·69 and the column is therefore unsatisfactory although it is of the same size and has the same ratio of reinforcement (3·14 per cent.) as the column with sixteen bars.

Since ratios of reinforcement exceeding 4 per cent. may lead to difficulties in placing concrete and cause congestion of reinforcement at joints, an economical column will have an area of reinforcement between, say, 1½ per cent. and 4 per cent. It is therefore possible to draw a line on the charts in *Figs.* 2, 3, 5, 8, 10 and 12 showing the values for the most economical column. Such a line is shown in *Fig.* 10. *Tables* I, II and III provide a rapid means of estimating the

TABLE II.—APPROXIMATE SIZES FOR EIGHT-BAR COLUMNS (1 : 2 : 4 CONCRETE).

$\frac{\sqrt{P}}{e}$ $(d = b)$	$\frac{\sqrt{P}}{e}$ $(d = 2b)$	$\frac{P}{p_{cc}bd}$	$r\frac{p_{sc}}{p_{cc}}$
3	2	0·1	0·77
7	5	0·2	0·75
13	9	0·3	0·73
20	14	0·4	0·72
28	20	0·5	0·71
37	26	0·6	0·71
55	40	0·7	0·62
80	55	0·8	0·53
120	85	0·9	0·45
185	130	1·0	0·39
320	220	1·1	0·34
720	510	1·2	0·31

P is in pounds (lb.). e is approximately $\sqrt{y^2 + \left(\frac{dx}{b}\right)^2}$.

For values of $\frac{P}{p_{cc}bd}$ less than 0·6, obtain the size from $\frac{Pe}{p_{cc}bd^2} = 0{\cdot}35$.

TABLE III.—APPROXIMATE SIZES FOR FOUR-BAR COLUMNS (1 : 2 : 4 CONCRETE).

$\frac{\sqrt{P}}{e}$ $(d = b)$	$\frac{\sqrt{P}}{e}$ $(d = 2b)$	$\frac{P}{p_{cc}bd}$	$r\frac{p_{sc}}{p_{cc}}$
2·5	2	0·1	0·71
7	5	0·2	0·64
13	9	0·3	0·59
19	14	0·4	0·56
27	19	0·5	0·56
40	29	0·6	0·51
60	40	0·7	0·46
85	60	0·8	0·42
130	95	0·9	0·38
200	140	1·0	0·34
350	250	1·1	0·32
800	570	1·2	0·30

P is in pounds (lb.). e is approximately $\sqrt{y^2 + \left(\frac{dx}{b}\right)^2}$.

For values of $\frac{P}{p_{cc}bd}$ less than 0·5, obtain the size from $\frac{Pe}{p_{cc}bd^2} = 0{\cdot}36$.

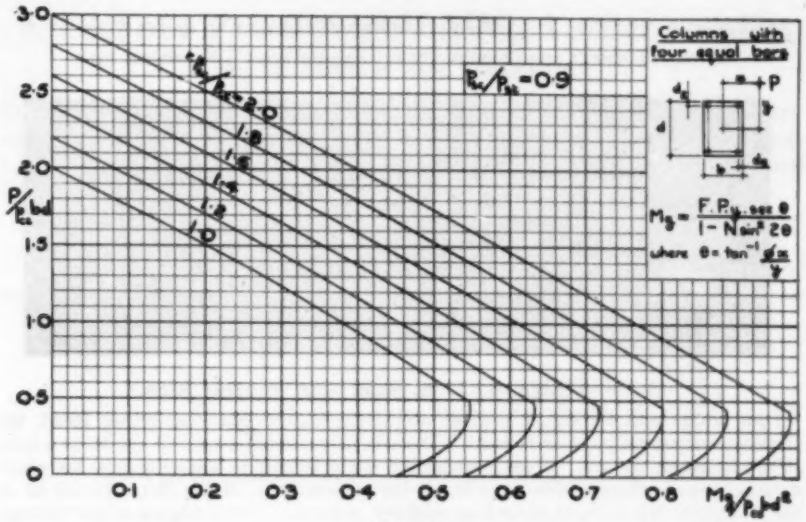


Fig. 12.

sizes of columns containing twelve or more bars, eight bars, or four bars respectively and were derived from the lines, representing the most economical column, drawn on the appropriate charts.

(To be continued.)

Water for Building Works.

THE National Federation of Building Trades Employers has been urging that water undertakings should adopt a more realistic way of calculating the charge for water used for building work than that of charging a fixed sum for every £100 of the contract price irrespective of the type of building or method of construction used. The British Waterworks Association has issued the following statement:

"The Association has been concerned for some time at the growing number of cases which builders have been taking to the Minister for him to decide the charge which should be made for building water under Section 27 of the Water Act, 1945. In those cases which have been taken to the Minister, the charges made by the water undertakings have been flat rate charges per £100 of the contract price irrespective of the amount of the contract price. In most cases the builder had asked for the supply to be metered. It does not appear that the Minister's determinations have been arrived at on any particular basis. The amounts which have had to be paid by the builder have been more than would have been charged if the supply had been taken by meter and something much less than the water undertaking required under its flat rate charge system. The Finance Advisory Committee has therefore carried out an examination of the quantities of water used for building different types of premises, from bungalows to office blocks. The evidence has shown that the quantity of water used is relatively not large. Therefore, where an authority has charged a flat rate per £100 for a large contract, the charge for water has not borne any relation to the quantity of water used. The Committee now therefore recommends that a flat rate charge based on the cost of the building should be made for water for building purposes, but that the builder should be given the option of taking the supply by meter."

This recommendation should ensure that contractors pay water undertakings only for the amount of water actually used.

FIFTY YEARS AGO.

From "Concrete and Constructional Engineering", November, 1910.

A Footbridge of 172-ft. Span with Precast Ribs.

"This bridge was erected to provide access to Cloghan Island at Mizen Head, the extreme south-west point of Ireland. The site necessitated a span of 172 ft. at a level of 150 ft. above the sea. A concrete bridge was preferred to a steel bridge, for which several cheaper designs were sent in, as the maintenance of the latter would be so costly and the life so short in such an exposed position. The bridge is of the through arch type, the ribs being parabolic curves with a versed sine of 30 ft., and are of rectangular section 3 ft. by 1 ft. at the springing, and 1 ft. 6 in. by 1 ft. at the crown. The ribs are parallel in the centre portion, 5 ft. 6 in. centres, but where the footway cuts through at the quarter spans they splay out, being 15 ft. centres at the abutments, and are connected by wind-bracing. The footway is 4 ft. 6 in. wide between the horizontal beams, and is 5 in. thick at the centre, including the granolithic surface; the beams are 15 in. by 9 in. The ribs were made in four portions, each on shore, and then built out from the abutments; they were in the form of a trough open at the top and connected with stirrups to prevent spreading. A wire ropeway was used to place the various parts in position, and the ribs were tied back to the rocks with wire ropes and were temporarily stiffened; the wind-bracing was then fixed and the ribs filled in, spaces being left to act as temporary hinges. The trestles and beams were then put in place. All these parts had been previously cast on shore. The floor and hangers were shuttered and made *in situ*, the shuttering being supported on the completed beams."

Lift-slabs separated by Explosives.

During the construction recently, by the lift-slab method, of a building in America, dynamite was used to separate the floor slab from the roof slab. The floor slab was cast and when hardened was used as the base on which the roof slab was cast. The two slabs failed to separate when jacking up the roof slab and 7500 sq. ft. of the floor slab was torn from its base. The two adhering slabs were therefore separated by small explosive charges. After making tests, it was decided to use 1-oz. charges of 40-per cent. gelatine dynamite in more than 3500 borings at 18-in. centres in one direction and at 12-in. centres in the other. Holes which were drilled through the $4\frac{3}{4}$-in. floor slab to the under-surface of the 7-in. roof slab were packed to a depth of 1 in. with clay followed by 1 oz. of gelatine with an instantaneous electrically-fired cap, and sealed with 2 in. of clay. The adhering slabs were separated by this means without damage to the roof slab. The work, which occupied three weeks and is described in a recent number of "The Explosive Engineer", was carried out by Burnbrae Inc., Chicago.

A Test of a Prestressed Precast Lattice Girder.

By G. LANTOS, B.Sc. (Budapest).

AN experimental prestressed precast lattice girder (*Fig.* 1) was tested to determine the suitability of such members for use as floor beams in a building where a cavity is required for pipes and ducts to be installed between a floor slab and the ceiling below.

Design and Construction.

The test girder was a three-quarter scale model of a girder of a span of 40 ft. It was assumed that such girders would be provided at 15 ft. centres

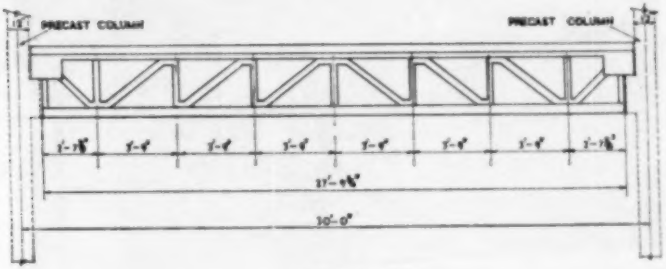


Fig. 1.

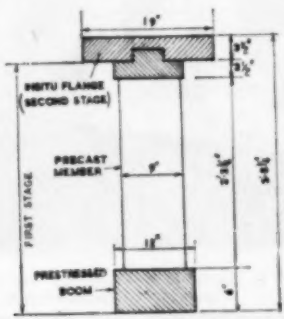


Fig. 2.—Cross-section of Girder.

in a floor. The loads assumed to act were a dead load of 128 lb. per square foot and an imposed load of 120 lb. per sq. ft. on the floor slab, and a dead load of 80 lb. per sq. ft. and an imposed load of 20 lb. per sq. ft. on the ceiling slab. The members were designed for axial forces only; secondary stresses were assumed to be insignificant.

The inclined and vertical members were precast but the upper and lower booms and the bearing blocks were cast in place. The lower boom was prestressed. The precast members were embedded ½ in. into the booms, and the reinforcement in tension in the precast members was anchored to the booms by means of mild

steel plates welded to the reinforcement bars and embedded in the booms. In this way it was possible to avoid undue congestion of reinforcement and at the same time the anchor-plates ensured the accurate spacing of the reinforcement.

The girder was assembled and cast in an upright position. First the prestressing wires were assembled on a stressing bed. The precast members were then placed in position and the wires tensioned. The moulds for the upper and lower booms were assembled and fixed to the precast members. The booms

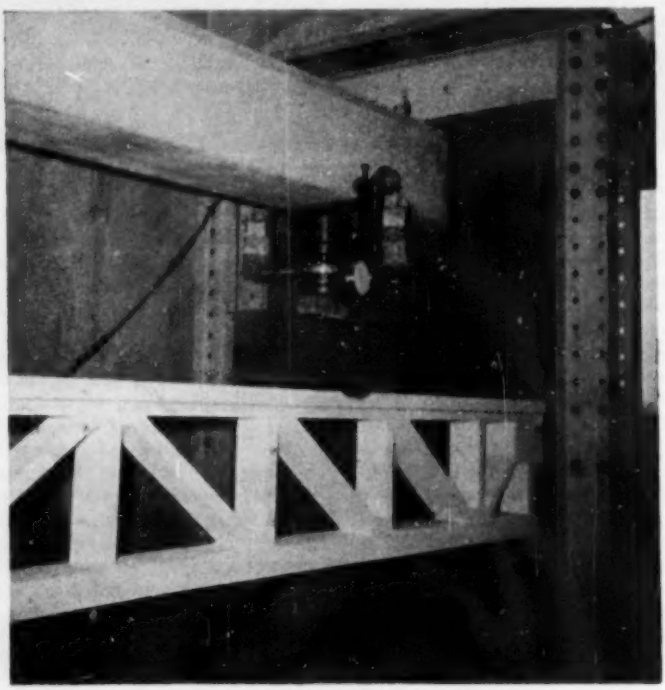


Fig. 3.

were concreted in two stages to simulate the conditions at a site, where precast floor slabs would form part of the compression flange of the girder. The lower boom and the lower part of the upper boom were cast in the first stage (*Fig.* 2). Two days later the flange of the upper boom was cast.

Testing.

The girder, which is shown under test in *Fig.* 3, was loaded at four places by means of two 50-ton jacks (*Fig.* 4). The objects of the test were to determine the efficiency of the connections of the precast members to the booms and to test the accuracy of the assumptions concerning the secondary stresses. The efficiency of the anchors was indicated by strain measurements made at the

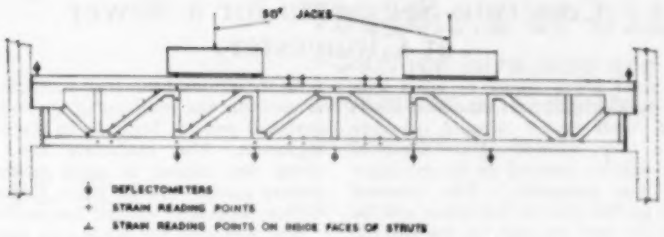


Fig. 4.—Arrangement for Testing.

critical junctions (*Fig.* 4). The magnitude of secondary stresses was indicated by measurements of strains at the faces of the members shown in *Fig.* 4.

The girder was subjected to repeated loadings, with the loads acting symmetrically as well as on only half the span. The loads applied were the design load, one-and-a-quarter times the design load, and one-and-a-half times the design load. Deflections and strains were measured simultaneously during each loading.

The anchors proved to be satisfactory. The assumption that secondary stresses can be ignored in the design of floor girders was justified. No considerable bending of the members was observed. The girder was finally loaded to destruction and failed when half the span was loaded with 3·3 times the design load. The failure occurred in the upper boom adjacent to, and on the inner side of, the point of application of the load nearest to the middle of the span. Bending became excessive in the upper boom due to the uneven deflection of the girder and was increased by the failure of the connections of the inclined members meeting at the middle of this boom. These connections were designed to resist only the small forces due to loads applied on half the span.

The lattice girder was designed by, and made and tested at the works of Concrete (Southern) Ltd. The writer wishes to thank the latter Company for permission to publish this article and Dr. F. W. Gifford for his collaboration.

Bulletins Received.

"**Manual of Current Practice for the Design, Construction, and Maintenance of Soil-Aggregate Roads.**" (Illinois: University of Illinois Bulletin, Volume 57, No. 23. 1959. Price 1.00 dollar.)

"**Archiwum Inzynierii Ladowej.**" Volume VI. Part 1. (Warsaw: Panstwowe Wydawnictwo Naukowe. 1960. Price 2500 zl.)
CONTENTS (in Polish with English summaries).—Cylindrical Shells on Elastic Foundation. Model Testing of Slabs and their Application to the Design of Slab Bridges. A Crack at the Edge of an Elastic Semi-plane. Ultra-sonic and Strength Tests of Gas Concrete.

"**Bulletin of the Polytechnic Institute of Jassy.**" Volume V. Parts 1 & 2. 1959. CONTENTS. — Articles, mainly mathematical, in various languages including Roumanian, Russian, English, French and German.

"**Temperature Measurements with Thermistors in Concrete.**" By K. E. C. Nielson. (Stockholm: Swedish Cement & Concrete Research Institute. 1959. Price Kr. 8.)

"**Rectangular Staircases without Beams.**" By J. Ferry Borges. (Lisbon: Laboratorio Nacional de Eugenhara Civil. Technical Paper No. 121. 1958. In English.)

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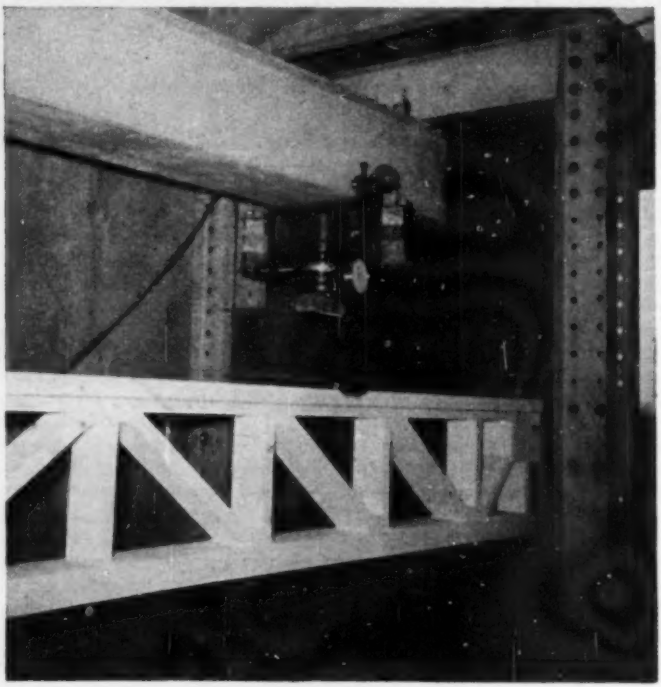

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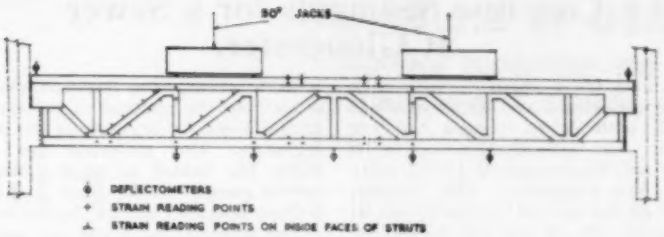

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Concrete Segments for a Sewer at Gloucester.

A NEW main sewer about 1¼ miles long at Gloucester is lined for a length of about 1660 yd. with bolted precast concrete segments (*Fig.* 1). A 1½-in. layer of concrete will be sprayed on to the inner face of the segments. The internal diameter of this part of the sewer will be 6 ft. 6 in. for 1080 yd. and 6 ft. for 580 yd. The remainder of the sewer will be of concrete pipe of 3-ft. 9-in. diameter, 400 yd. of which will be laid in tunnel and 170 yd. in trench from 7 ft. to 16 ft. 6 in. deep. Thirteen manholes from 30 ft. to 50 ft. deep are to be provided. Six of the manholes are of 9-ft. diameter and will be lined with precast concrete segments. In some cases, the manholes will not be on the line of the sewer and access will be by means of a short tunnel entering the side of the sewer. The manhole to which access is easiest is near the middle of the length of the sewer and tunnelling proceeded in both directions from this manhole, which is used for the removal of the excavated material and for bringing in the concrete segments. The materials are carried along the tunnel in skips running on narrow-gauge tracks and driven by battery-operated electric locomotives.

The segments are made at a temporary precasting yard set up on an adjacent rubbish tip (*Fig.* 2). The yard is arranged around two parallel narrow-gauge rail tracks on which run sixty-nine bogies each carrying the steel mould for one segment. The moulds are lifted off the bogies on to a vibrating table where the segments are cast and vibrated. The filled mould is then replaced on the bogie, which is pushed along the line where it remains during initial hardening of the concrete. Two days after casting, the mould is dismantled, the segment is removed, and the mould is reassembled for re-use. During the winter a large poly-

Fig. 1.—Part of the Lined Sewer.

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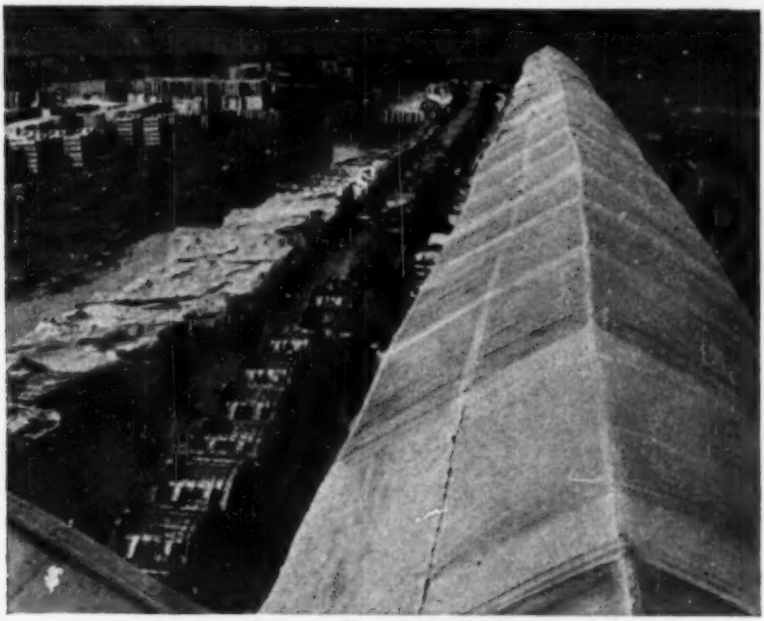

Fig. 2.—The Casting Yard.

thene cover was erected over part of the track (*Fig.* 2) and the air within was heated. Concreting and curing took place beneath the cover. The segments are cured for seven days and are stored in the open for about six weeks before use.

The sewer is being constructed under the supervision of Mr. J. H. Goodridge, the City Engineer and Surveyor. The consulting engineers are Messrs. John Taylor & Sons, and the general contractors are Messrs. Howard Farrow, Ltd.

Lectures on Building.

THE following lectures have been arranged by the Ministry of Works. Admission is free.

The R.I.B.A. Form of Contract. By I. N. Duncan Wallace. Mid-Warwickshire College of Further Education, Warwick New Road, Leamington Spa, November 1, 7.15 p.m.; and by D. Gardam. Technical College, Bolton, November 24, 7.15 p.m.

Practical Formwork Design and Construction for Concrete. By J. G. Richardson. City College and Art School, Ipswich Road, Norwich, November 3, 7 p.m.

Prestressed Concrete. By H. Kaylor. College of Technology, Anglesea Road, Portsmouth, November 9, 7.15 p.m.

Concrete Construction in Scotland. By P. Russell. Temperance Hotel, Falkirk, November 16, 7.15 p.m.; and Laudus Restaurant, Kilmarnock, November 22, 7.15 p.m.

Clerical Methods in Builders' Offices. By K. C. Symons. County Technical College, Reigate Road, Ewell, November 28, 7.15 p.m.

Dulles International Airport.

Two of the four runways, each 11,500 ft. long and 150 ft. wide, at the new Dulles International Airport near Washington, D.C., have now been completed. Each runway is constructed in six strips 25 ft. wide, the two outer and two central strips being 12 in. thick. The sub-base is 9-in. of crushed stone. The concrete batching and mixing plant incorporates three 10-cu. yd. mixers and is said to be the largest in the world. About 5000 cu. yd. of concrete is mixed daily.

CROSS-SECTIONAL AREAS OF REINFORCEMENT BARS

SQUARE INCHES AND SQUARE CENTIMETRES

Diam.		Inch m.m.	1/4 (4·76)	6	1/4 (6·35)	5/16 (7·94)	8	3/8 (9·52)	10	7/16 (11·1)	12	1/2 (12·7)	14	9/16 (15·9)	16	18	5/8 (19·1)	20	22	7/8 (22·2)	24	1 (25·4)
NUMBER OF BARS	1	sq. in.	0·028	0·044	0·049	0·077	0·078	0·110	0·122	0·150	0·175	0·196	0·238	0·307	0·312	0·394	0·442	0·487	0·589	0·601	0·701	0·785
		sq. cm.	0·178	0·283	0·317	0·495	0·502	0·71	0·785	0·968	1·13	1·27	1·54	1·98	2·01	2·54	2·85	3·14	3·80	3·88	4·52	5·07
	2	sq. in.	0·055	0·088	0·098	0·153	0·156	0·221	0·244	0·301	0·350	0·393	0·476	0·614	0·624	0·788	0·884	0·974	1·18	1·20	1·40	1·57
		sq. cm.	0·362	0·566	0·632	0·994	1·00	1·42	1·57	1·94	2·26	2·53	3·08	3·96	4·02	5·08	5·70	6·28	7·60	7·75	9·05	10·13
	3	sq. in.	0·082	0·131	0·147	0·230	0·234	0·331	0·365	0·451	0·526	0·589	0·715	0·920	0·935	1·18	1·33	1·43	1·77	1·80	2·09	2·36
		sq. cm.	0·529	0·848	0·948	1·48	1·51	2·14	2·35	2·91	3·39	3·80	4·62	5·94	6·03	7·63	8·55	9·25	11·40	11·64	13·57	15·23
	4	sq. in.	0·110	0·175	0·196	0·307	0·313	0·442	0·487	0·601	0·701	0·785	0·954	1·23	1·25	1·57	1·77	1·95	2·36	2·41	2·80	3·14
		sq. cm.	0·71	1·13	1·26	1·98	2·01	2·85	3·14	3·88	4·52	5·06	6·16	7·92	8·04	10·18	11·40	12·57	15·20	15·55	18·09	20·26
	5	sq. in.	0·138	0·219	0·245	0·384	0·392	0·552	0·608	0·752	0·876	0·982	1·19	1·53	1·63	1·89	2·21	2·43	2·94	3·01	3·51	3·93
		sq. cm.	0·89	1·41	1·58	2·48	2·51	3·56	3·93	4·85	5·65	6·34	7·70	9·90	10·05	12·22	14·26	15·71	19·0	19·41	22·62	25·35
	6	sq. in.	0·165	0·263	0·295	0·460	0·476	0·663	0·730	0·902	1·05	1·18	1·43	1·84	1·87	2·36	2·65	2·92	3·53	3·61	4·21	4·71
		sq. cm.	1·07	1·70	1·90	2·97	3·02	4·28	4·71	5·82	6·79	8·24	9·24	11·88	12·06	15·26	17·09	18·85	22·81	23·29	27·14	30·39
	7	sq. in.	0·193	0·307	0·344	0·537	0·546	0·773	0·852	1·05	1·23	1·37	1·67	2·15	2·18	2·76	3·09	3·38	4·12	4·21	4·90	5·50
		sq. cm.	1·25	1·98	2·22	3·46	3·52	4·99	5·50	6·79	7·92	8·86	0·77	13·87	14·07	17·81	19·93	21·82	26·61	27·16	31·66	35·48
	8	sq. in.	0·221	0·350	0·393	0·614	0·623	0·884	0·973	1·20	1·40	1·57	1·91	2·45	2·49	3·15	3·53	3·90	4·71	4·81	5·60	6·28
		sq. cm.	1·43	2·26	2·54	3·96	4·02	5·70	6·28	7·75	9·05	10·13	12·31	15·81	16·08	20·35	22·77	25·14	30·41	31·03	36·18	40·52
	9	sq. in.	0·248	0·394	0·442	0·690	0·705	0·994	1·10	1·35	1·57	1·77	2·15	2·76	2·80	3·47	3·98	4·38	5·30	5·41	6·31	7·07
		sq. cm.	1·60	2·55	2·85	4·45	4·52	6·41	7·07	8·73	10·18	11·40	13·85	17·80	18·09	22·40	25·68	28·28	34·21	34·90	40·71	45·61
	10	sq. in.	0·276	0·440	0·491	0·767	0·784	1·10	1·22	1·50	1·75	1·96	2·38	3·07	3·12	3·79	4·42	4·87	5·89	6·01	7·06	7·85
		sq. cm.	1·78	2·83	3·17	4·95	5·02	7·10	7·85	9·68	11·31	12·64	15·39	19·81	20·10	25·44	28·52	31·42	38·01	38·77	45·24	50·65

Metric System.

(See page 397.)

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The Severn Bridge.

TENDERS were invited recently for the construction of the foundations and substructure of the new bridge across the River Severn between Aust, Glos., and Beachley, Mon. The superstructure will be a suspension bridge having a main span of 3240 ft., and will be the fifth largest span in the world. The cost is expected to be £11,000,000. A further sum of £5,000,000 will be expended on the Wye bridge, viaduct, and approach road works which are included in the scheme which is expected to be completed in 1966.

The initial work includes the construction of two main piers forming the bases of the steel towers, the anchorages for the main cables, the approach viaduct on the eastern bank, and the access road. The eastern main pier, on the Aust side of the river, and the eastern anchorage will be constructed on the tidal foreshore of the river, using hollow precast concrete blocks, which will be placed in position at low tide, and connected with cast-insitu reinforced concrete. The pier will be solid and will be 140 ft. long, 42 ft. wide and 63 ft. high. The anchorage will be a pair of blocks, 145 ft. long, 40 ft. wide and 120 ft. high, separated by an enclosed space and each containing chambers and galleries. The western main pier will be similar to the eastern, but will be supported on caissons. The western anchorage will be similar to the eastern but constructed on dry land. The eastern approach viaduct will extend to the eastern anchorage in three spans of 170 ft. each. The bridge over the River Wye will be 1340 ft. long. It is estimated that 40,000 tons of steel and 120,000 tons of cement will be required for the two bridges and approach viaducts.

The schemes for the two bridges and the immediate approach roads were prepared by Messrs. Mott, Hay & Anderson acting as consulting engineers in association with Messrs. Freeman, Fox & Partners. Sir Percy Thomas is the consulting architect. The design of the Severn Bridge is being considered by the Royal Fine Art Commission.

[The other bridges of long span are the new Forth Road bridge (3300 ft.), the Golden Gate bridge at San Francisco (4200 ft.), the George Washington bridge in New York (3500 ft.), and the new Mackinac Bridge in Michigan (3800 ft.); they are all steel suspension bridges on concrete substructures.—ED.]

Accurate Construction of an Insulated Floor.

THE requirements of the specification for the construction of the floor of the new television studios for Associated Rediffusion at Wembley were particularly severe. The floor had to be finished level to a tolerance of $\pm \frac{1}{16}$ in. in 20 ft., and it has to be free from the effects of settlement, expansion or contraction due to thermal changes and shrinkage, waterproof, resistant to rising water vapour, insulated from the main structure and adjoining buildings against the transmission of impact and structure-borne noises, and insulated against the transmission of impact noise between the two parts of the studio. The floor has to withstand the effects of 2-ton camera-dollies and support the weight of vertically lifted partitions which is equivalent to 1320 lb. per linear foot.

The walls and roof of the building were constructed before commencing the excavation for the floor to prevent shrinking or swelling of the clay subsoil.

After excavating for one part of the floor down to formation level, a 4-in. bed of dry hoggin was spread in strips 16 ft. wide and compacted with a 15-cwt. vibrating roller. Concrete blinding 2 in. thick was then laid and vibrated. The

floor is an 8-in. reinforced concrete slab with a special finish coating. The slab was laid in 15-ft. square bays in chequerboard pattern on waterproofed building paper laid on the blinding. Metal road-forms, perforated for the passage of the reinforcement bars, were used.

The aggregates, which comprised 65 per cent. of graded ¾-in. coarse material and 35 per cent. of fine aggregate, were mixed in the proportions of 5·8 to 1 with sulphate-resistant cement. The water-cement ratio of the concrete was 0·45 and the crushing strength at twenty-eight days was 8000 lb. per square inch. The concrete was consolidated with a vibrating roller except close to the side-forms where a pneumatic rammer was used. At least four days elapsed between concreting adjacent bays. The slabs were covered with polythene sheets during curing.

Levelling in connection with the concrete slab was carried out with an " Auto-set " level and precise staves. The resultant surface was + 0 and − ¾ in. at three small areas only in 14,000 sq. ft. of floor and was therefore well within the ½ in. tolerance allowed in the specification for the slab.

At the perimeter walls a 2-in. gap is provided, and is filled with cork for acoustic purposes, and allows for shrinkage of the concrete.

The finish coating of the floor is ¾-in. asphalt, 2-in. insulating screed, and 4·5 mm. of linoleum. The small tolerances allowed in the specification were achieved by providing levelling screws located on a 10-ft. grid. On the screws, metal screeds were placed; the tops of the screws were adjusted with the " Auto-set " level to which an optical micrometer was added.

Fire-resistance of Prestressed Concrete.

In a paper entitled " The Fire-resistance of Prestressed Concrete Beams ", published in the Proceedings of the Institution of Civil Engineers, September, 1960, Mr. L. A. Ashton and Mr. S. C. C. Bate give the result of an investigation of the behaviour of beams with post-tensioned cables. The tests were carried out by the Joint Fire Research Organization in association with the Building Research Station. The principal conclusions are as follows.

As with other forms of construction, sufficient fire-resistance can be attained with prestressed concrete beams when proper attention is given to the design. The results of the tests, which are primarily applicable to freely-supported composite prestressed concrete beams with post-tensioned cables of hard-drawn steel wire, indicate that failure of a beam supporting its design load will occur when the mean temperature of the prestressing steel reaches about 400 deg. C. Fire-resistance depends on the protection given to the steel. A fire-resistance of one hour is obtained when the cover of concrete over the prestressing steel is 1½ in. Resistance for two or four hours is obtained with covers of 2½ or 4 in. respectively, provided that the cover is retained in position with secondary reinforcement.

A substantial increase in the fire-resistance of a beam is obtained by the application of some form of insulation to its exposed surfaces, provided that the adhesion of the insulation to the concrete is ensured for the whole of the period of the fire. Precast slabs of lightly-reinforced vermiculite concrete, used as a lining of the mould when casting the beam, are equivalent in insulating value to about twice their thickness of concrete. Evidence from other tests suggests that smaller thicknesses of vermiculite-gypsum plaster or sprayed asbestos, in each case applied directly to the surface of the beam, should provide similar insulation to that obtained in the tests with vermiculite concrete, being equivalent to a maximum of three times their thickness of concrete.

The failure of prestressed concrete beams with secondary reinforcement is gradual, and is accompanied by large deflections which give ample warning of collapse.

If the temperature of the steel in a prestressed concrete beam exposed to fire has exceeded about 180 deg. C., the reduction in the stiffness of the beam is likely to be severe and will normally necessitate replacement of the structural member.

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celsius See THERMOMETER (person)

celt 1. *n.*, chisel-edged prehistoric tool (imaginary L.)

celt 2. *n.*, *(pl.)* peoples speaking or having spoken languages akin to that of the Gauls (Bretons, Cornish, Welsh, Irish, Manx, Gaels) *(sing.)* member of such people.

celtic *(adj.;* -ically) of the Cc. (Celtic fringe, the Scots, Irish, Welsh and Cornish, in relation to the U.K.) *(n.)* the Celtic language, celticism, celtomania, celtomaniac, celtophobe, celtophobia. *nn.* (L. Celta)

cement 1. *n.*; **Substance made by calcining lime and clay, applied as paste and hardening into stony consistence, and used as material for floors and walls and tanks or as mortar: TUNNEL C. is particularly strong, rapid hardening, weather resistant c. Best C.** *see* **The Tunnel Portland Cement Company Limited, 105 Piccadilly, London W.1 GROsvenor 4100.**

cement 2. *v.t.* **Apply c. to, line or cover with c., unite (as) with c. To C. for best results** *see* **TUNNEL**

cemetery *n.*, Burial ground other than churchyard (Gk. Koimao, put to sleep)

cenobite *see* COENOBITE

cenotaph (-ahf) *n.* Sepulchral monument to one whose remains are elsewhere.

censer *n* Incense-burning vessel. Cense *v.t.* adore or perfume with incense (INCENSE 2)

censor 1. *n.* Ancient-Roman supervisor of census and public morals: modern official examining plays, books, news, correspondence, etc. to suppress what is immoral or seditious or (esp. in war) inopportune· person assuming the right of judging others. **2.** *v.t* Examine or make excisions etc. as in c. **Censorial** *a.*, (-lly), of Roman or modern c.; **censorious** *a.* fault-find-

Patent Applications.

Cooling Towers.

FIG. 2.

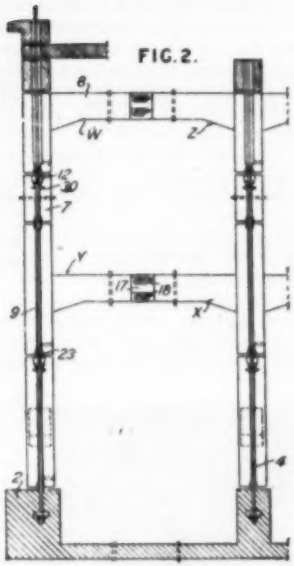
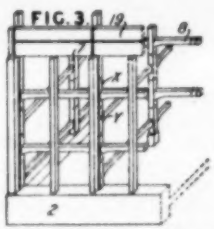


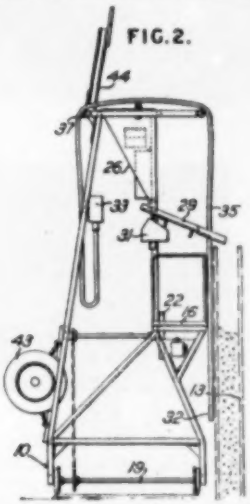
FIG. 3.



A COOLING tower is constructed from prefabricated concrete building elements X, Y, Z, W each of which comprises a vertical part 7 and a horizontal part 8. The vertical parts are superposed in columns and have holes bored through them to house stress rods 9 which are anchored in the rim 2 of the foundation. Nuts 12 engage dished members 30 to stress the rods which are connected together by bushings 23. Adjacent arms 8 are held together by joining reinforcing wires 18 and filling the gap 17 with cement. The structure is built such that in adjacent stories the arms 8 are at right angles. Wall plates 19 overlap horizontally and are held by vertical weather strips. The rods 4 extend above the top of the building elements to support a flange beam, roof plates and moulding beams placed over the roof plates and may support a railing and a suspension rod for a jib crane. Some of the arms 8 may protrude from the side of the building to support a staircase.—No. 8727/57. E. Kirchner. March 16, 1957.

Supplying Concrete to Shuttering.

FIG. 2.



Concrete is placed in wall shuttering 13 from a hopper 26 and chutes 29 carried by a wheeled carriage 10 also carrying a platform 16 for operators, the carriage being advanced manually by turning a spoked wheel 22 geared to a carriage axle 19 and vibrators 32 for the placed concrete are driven through flexible drives 35 by motors 33. The flexible drives are supported on long rollers 37 and the weight of the vibrators is balanced by a bight of cable. The chutes 29 are adjustable in length and swivel and have vibrators 31. The apparatus has road wheels 43 and a towing bar 44 so that it can be trailed behind a vehicle.—No. 827,544. Unit Construction Co., Ltd., P. Hands, and J. L. Hutter. November 13, 1957.

New Vibrating Rollers.

SEVERAL new types of vibrating roller are being made by Messrs. E. P. Allam & Co., Ltd. In each case standard electric vibrating motors are fixed within the roller and are driven by alternators of the permanent-magnet type providing a variable frequency and voltage for the motors. Variation of the frequency of vibration is regulated by adjusting the speed of the motor.

Fig. 1.

The smallest of the rollers, which is 17 in. in diameter and 21 in. wide, is propelled by hand and incorporates one motor 22½ in. in diameter and 26 in. wide. The roller of medium size (*Fig.* 1) is guided by hand, but the roller is propelled mechanically. Two vibrating motors rotating in opposite directions provide the vibration, but each combine to transmit a concentration of force vertically to the material being consolidated. Tandem rollers (*Fig.* 2) of size and design similar to the medium roller are also available. The compacting force is slightly greater. The alternator and control switches are attached to the tractor, which tows the rollers. The contra-rotating motors are interchangeable between the medium and tandem machines, as are also the rollers. The number of rollers are varied to suit the width of the area to be compacted. A roller of 21-in. diameter but only 12 in. wide is obtainable for working in trenches.

Fig. 2.

The weights of equivalent non-vibrating rollers are claimed to be 25 cwt. for the smaller roller, 1½ tons for the trench roller, and upwards of 2½ tons for the medium roller. The rollers can be used for compacting asphalt, macadam, soil-cement, gravel, " dry-lean " concrete, and " earth-damp " concrete.

Reinforced Concrete Association.

THE subjects of papers to be read at the meetings of the Reinforced Concrete Association to be held at 11 Upper Belgrave Street, London, S.W.1, during the early part of 1961 are as follows.

January 18.—" Structural Analysis and Digital Computers." By J. Munro and A. Edwards.

February 15.—" Hyperbolic Paraboloids." By J. D. Bennett, with contributions from H. Gorst, Mrs. C. Hume, and H. S. Scorer.

March 15.—Symposium on " Large Diameter Bored Piles ". The authors will include M. J. Tomlinson, J. A. Derrington, W. G. K. Fleming, M. W. Leonard, and D. J. Palmer.

Particulars of meetings to be held in Manchester, Liverpool, Birmingham, Bristol, Cardiff, Glasgow, and Edinburgh can be obtained from the Secretary, 94 Petty France, London, S.W.1.

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SITUATIONS VACANT. Consulting engineers require in their London office experienced reinforced concrete designers and designer/detailers. Also experienced detailers willing to learn design. Five-days' week. Good salaries for the right people. Apply, in writing, to S. ZUKAS, CHIEF ENGINEER, JOHN DE BREMAEKER & PARTNERS, 3 Southampton Place, London, W.C.2.

SITUATIONS VACANT. Reinforced concrete detailers required by LEONARD & GRANT in their South London drawing offices. Only top men should apply. High salaries. Interview by appointment. Telephone Tate Gallery 8496.

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SITUATIONS VACANT. A vacancy exists for a reinforced concrete designer or an experienced designer-detailer and for an experienced detailer draughtsman. Good prospects. Varied and interesting work. Luncheon vouchers. 5-days' week. Apply, with particulars of experience and salary required, to JOHN F. FARQUHARSON & PARTNERS, 34 Queen Anne Street, London, W.1.

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SITUATIONS VACANT. Air Ministry Works Designs Branch requires in London structural engineering designer-draughtsmen for reinforced concrete or structural steelwork of all types. Applicants must have adequate training and several years' experience. Some site experience and possession of recognised technical qualification an advantage. Financial assistance and time off may be allowed for recognised courses of study. Promotion and pension prospects. 5-days' week with 18 days paid leave per year initially.

Salary ranges from £805 (age at 25) to £980 per annum. Commencing salary dependent on age, qualifications and experience. Applicants, who must be natural born British subjects, should write (quoting Order No. Kings Cross 3745) to AIR MINISTRY W.G.d., Lacon House, Theobalds Road, London, W.C.1, or to any Employment Exchange, giving age, details of training, qualifications, full particulars of former posts held and copies of any testimonials. Candidates selected will normally be interviewed in London and certain expenses reimbursed.

SITUATION VACANT. Engineer required by consultants for research and development of new methods of design and the use of new materials for structures of large spans and/or 4-storeys high, as well as traditional structural and civil engineering work. Pension scheme. Luncheon vouchers. 3-4 weeks' holiday. Please apply to B. H. Fisher, of A.M. GEAR & ASSOCIATES, 12 Manchester Square, London, W.1. Telephone: Hunter 0331.

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SITUATION VACANT. Qualified young engineer-designer required by London consulting engineers. Good background of drawing office and other experience in reinforced concrete work is essential. Work will be primarily in drawing office, but successful applicant will assist executive with technical administration work, organisation, correspondence, accounts, estimating, etc. Good prospects for smart and alert applicant who can take things as they come. Starting salary about £1250. Applications with full details in confidence to Box 4706, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

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SITUATIONS VACANT. Consulting Engineer, Victoria, requires assistants with several years' experience in reinforced concrete. Apply in writing to JAMES E. WARDROPPER, 50 Belgrave Road, London, S.W.1.

SITUATIONS VACANT. Designer-detailers required preferably qualified but minimum standard H.N.C. with several years' drawing office experience in reinforced concrete. Age range 25–40 and able to work on own initiative. Applications in writing to JOHN LIVERSEDGE & ASSOCIATES, 42 Portland Place, London, W.1.

SITUATIONS VACANT. Experienced reinforced concrete designer-detailers and detailers required for varied and interesting work. Write, giving age and experience, to HILLS STRUCTURES & FOUNDATIONS, LTD., Heather Park Drive, Wembley.

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Due to increased turnover, two additional first-class Supervisors are required by well-known Concrete Specialists. Experienced men, preferably used to handling long-term contracts but top Foremen with good all-round experience considered. Good salary and conditions. Apply BOX 4700, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

REINFORCED CONCRETE
DESIGNER-
DRAUGHTSMEN
required by
Consulting Engineers
Varied work and good salaries to the right men. South Bank. Reply, stating age, experience, and salary required, to BOX 4708, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1

ADMINISTRATIVE COUNTY
OF LEICESTER
Appointment of Senior Bridge Engineer
Applications are invited from suitably qualified engineers for the above appointment in Salary Scale "A" (£1410 rising to a maximum of £1565 per annum). Starting salary dependent on qualifications and experience, which need not necessarily have been in the service of a local authority. An essential-user car allowance on the County Scale will be paid.
Forms of application obtainable from the County Engineer and Surveyor, County Offices, Grey Friars, Leicester. Closing date, November 17th, 1960.
JOHN A. CHATTERTON
Clerk of the County Council
Grey Friars,
Leicester.

Modular concrete
ASSISTANT ESTIMATOR/SURVEYOR
is required for the CONSTRUCTION DIVISION of the Modular Concrete Co. Ltd.
The work will include the preparation and pricing of estimates, both from Bills of Quantities and drawings, together with taking-off, preparation of valuations and final accounts.
To the right man there is every opportunity for advancement in this rapidly developing organisation. Generous profit sharing, savings and superannuation schemes are in operation.
Write fully stating age, qualifications, detailed experience and present salary to Personnel Manager,
MODULAR CONCRETE CO. LTD.,
1260 London Road, Norbury, S.W.16.

SITUATIONS VACANT. Draughtsmen with 3 years' experience detailing reinforced concrete structures required by Norman & Dawbarn, 7 Portland Place, London, W.1.

SITUATION VACANT. Civil Resident Engineer (Assistant) required by major industrial company. Must have design and site experience of reinforced concrete industrial construction and preferably degree. Age not less than 27 years. Salary in range £1000/£1250 per annum. Give full details, including age, to Box CE.934, L.P.E., Romano House, 399/401 Strand, London, W.C.2.

STAFFORDSHIRE COUNTY COUNCIL

County Architect's Department

Applications are invited from suitably qualified candidates for the following posts:—

STRUCTURAL ENGINEERING SECTION—

(*a*) SENIOR ASSISTANT ENGINEER—Grade Special/IV, commencing within the Special Grade (£840–£1145 per annum), according to qualifications and experience. Applicants should be Chartered Structural or Civil Engineers with good experience in the design of structures in steelwork, reinforced concrete, and structural timber. Experience in the design of reinforced concrete building frames an advantage.

(*b*) STRUCTURAL DRAUGHTSMAN—Salary Scale A.P.T. II (£815–£960 p.a.). Applicants should have good general knowledge of Structural Engineering and be neat and expeditious draughtsmen. Duties include preparation of detail drawings in steelwork, reinforced concrete, and structural timber. Minimum qualifications required are graduateship of the Institution of Structural Engineers, or Higher National certificate.

The appointments will be subject to:—

(*a*) The National Scheme of Conditions of Service.

(*b*) The Local Government Superannuation Acts and the passing of a medical examination.

The County Council are prepared to grant a lodging allowance of 35s. per week to married applicants maintaining a home outside the geographical County for a period of six months, also second-class rail travel home every second month during the initial six months. The Council are also prepared to give consideration to the granting of financial assistance in appropriate cases towards removal expenses.

The Council has a scheme for loans to employees wishing to purchase their own houses.

Forms of application, which must be returned by the 30th November, 1960, may be obtained from P. Woodcock, F.R.I.B.A., County Architect, Green Hall, Lichfield Road, Stafford.

T. H. Evans,
Clerk of the County Council.

SITUATIONS VACANT. Civil Design Engineers and Designer/Draughtsmen required by leading industrial company. Must have had experience of design of heavy reinforced concrete industrial structures and preferably some site experience. Salary in range £900/£1300 per annum. Give full details, including age, to Box C.E.933, L.P.E., Romano House, 399/401 Strand, London, W.C.2.

CIVIL/STRUCTURAL ENGINEER

Applications are invited from Corporate Members of the Institution of Civil/Structural Engineers for a permanent appointment in the Civil Engineering Section of the National Coal Board, West Midlands Division, Himley Hall, nr. Dudley, Worcs.

The appointment will be within the salary range of £1000–£1550 per annum, and the starting salary will be commensurate with qualifications and experience.

The Division has on hand a large programme of interesting work offering experience of a varied nature. The appointment is superannuable. Applications quoting CCE on forms obtainable from Divisional Chief Staff Officer, National Coal Board, Himley Hall, nr. Dudley, Worcs. To be returned by November 26th, 1960.

SERVICES OFFERED.

SERVICES OFFERED. Qualified and experienced engineers offer complete and prompt service to the profession for all types of reinforced concrete work. Estimates, design and detailing. Box 4709, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

SERVICES OFFERED. Structural engineer with group of assistants offers quick, accurate design and detailing service. Satisfaction assured. Box 4711, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

FOR SALE AND WANTED.

FOR SALE. Steel plates and sections to size. Also tubes up to 10 in. N/B. E. Stephens & Son Ltd., Bath Street, London, E.C.1. Clerkenwell 1731.

WANTED. Concrete tube-testing machine. Box 4710, Concrete and Constructional Engineering, 14 Dartmouth Street, London, S.W.1.

WANTED. No. 3 or 4 Liner Cumflow with batch loader—similar machine considered. Price to W. G. Smith, Concrete Works, Watling Street, Cannock, Staffs.

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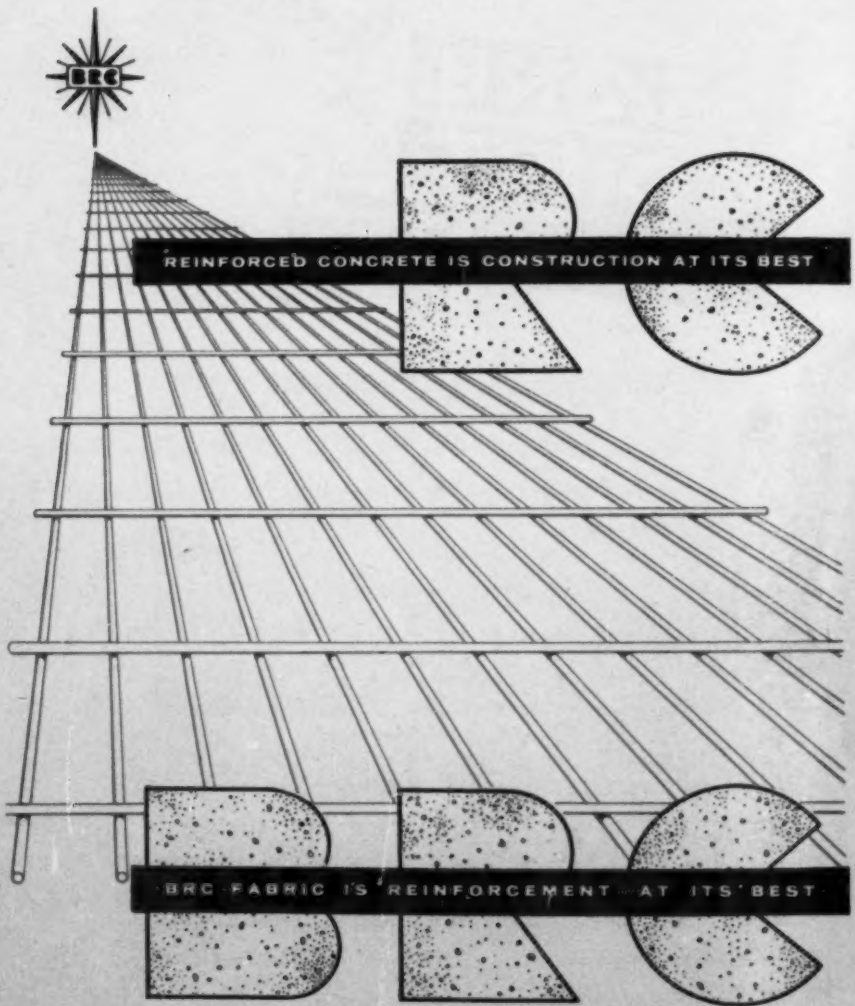

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